Structural Ambiguity in Montague Grammar and Categorial Grammar

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Abstract

We give a type logical categorial grammar for the syntax and semantics of Montague's seminal fragment, which includes ambiguities of quantification and intensionality and their interactions, and we present the analyses assigned by a parser/theorem prover CatLog to the examples of the first half of Chapter 7 of the classic text *Introduction to Montague Semantics* of Dowty, Wall and Peters (1981).

Keywords: categorial grammar, displacement calculus, intensionality, modal categorial logic, Montague Grammar, parsing as deduction, quantification, type logical grammar.

1 Introduction

Logical semantics came into being with Montague Grammar: Montague (1970b) (UG), Montague (1970a) (EFL), and Montague (1973) (PTQ), which introduced into linguistics tools like lambda calculus and intensional logic, and algebraic compositionality, and exemplified the paradigm with a grammar for a well-known fragment including quantification, intensionality and anaphora and, significantly, their interactions. Type logical categorial grammar reduces grammar to logic: an expression is grammatical if and only if an associated sequent is a theorem (Moortgat 1988; Morrill 1994; Moortgat 1997; Carpenter 1997; Jäger 2005; Morrill 2011b; Moot and Retoré 2012). In such categorial grammar type-logical semantics is assigned by the constructive reading of a syntactic proof as a semantic lambda term. In this paper we consider type logical categorial grammar for the Montague fragment.

The conventional understanding is that grammar should assign "structural descriptions" to grammatical sentences, and that where there is structural ambiguity there should be multiple structural descriptions corresponding to the different readings. But in what sense is a structural description in isolation correct or incorrect, and in what way do multiple structural descriptions represent the semantic properties of different readings?

In Montague Grammar the structural descriptions are either the bracketed expressions to which the ambiguating relation applies (EFL) or the analysis trees (PTQ). In both cases a structural description determines truth conditions so that there is semantic commitment in the structural attribution. Furthermore the semantic interpretation of syntactic structural descriptions is compositional, indeed a homomorphism from syntax to semantics. Because semantic interpretation is functional and not just relational it follows that ambiguity can *only* arise from lexical or syntactic ambiguity, and in this sense compositionality *explains* the conventional understanding of structural ambiguity stated in the first paragraph.

In this paper we illustrate how logical categorial grammar refines Montague grammar's treatment of ambiguity. If Montague Grammar renders compositionality as algebra, categorial grammar further refines it as algebraic *logic*, and compositionality is a homomorphism from syntactic (categorial) *proofs* to semantic (intuitionistic) *proofs*.

In Section 2 we define the type logical formalism within which we work. In Section 3 we define the grammar for the fragment. Since type logical grammar is purely lexicalist the grammar is just a lexicon. The type calculus projecting language from the lexicon is universal. In Section 4 we provide and discuss the output of the parser/theorem-prover CatLog (Morrill 2011a; Morrill 2012) for representative example sentences, those for which analysis trees are given in the first half of Chapter 7 of Dowty, Wall and Peters (1981). We conclude in Section 5.

2 Formalism

2.1 Semantic representation language

The set $\mathcal{T}$ of *semantic types* is defined on the basis of a set δ of *basic semantic types* as follows:

(1) $\mathcal{T} ::= \delta \mid \top \mid \mathcal{T} \to \mathcal{T} \mid \mathbf{L}\mathcal{T}$

A *semantic frame* comprises a non-empty set W of worlds and a family $\{D_\tau\}_{\tau \in \mathcal{T}}$ of non-empty *semantic type domains* such that:

(2)
$$\begin{array}{rcll} D_\top & = & \{\emptyset\} & & \text{singleton set} \\ D_{\tau_1 \to \tau_2} & = & D_{\tau_2}^{D_{\tau_1}} & \text{the set of all functions from } D_{\tau_1} \text{ to } D_{\tau_2} & \text{functional exponentiation} \\ D_{\mathbf{L}\tau} & = & D_\tau^W & \text{the set of all functions from } W \text{ to } D_\tau & \text{functional exponentiation} \end{array}$$

The sets Φ_τ of *terms* of type τ for each type τ are defined on the basis of sets C_τ of constants of type τ and denumerably infinite sets V_τ of variables of type τ for each type τ as follows:

(3)
$$\begin{array}{rcll} \Phi_\tau & ::= & C_\tau & \\ \Phi_\tau & ::= & V_\tau & \\ \Phi_\top & ::= & t & \\ \Phi_\tau & ::= & (\Phi_{\tau' \to \tau}\ \Phi_{\tau'}) & \text{functional application} \\ \Phi_{\tau \to \tau'} & ::= & \lambda V_\tau \Phi_{\tau'} & \text{functional abstraction} \\ \Phi_\tau & ::= & {}^\vee\Phi_{\mathbf{L}\tau} & \text{extensionalization} \\ \Phi_{\mathbf{L}\tau} & ::= & {}^\wedge\Phi_\tau & \text{intensionalization} \end{array}$$

Given a semantic frame, a *valuation* f is a function mapping each constant of type τ into an element of D_τ, and an *assignment* g is a function mapping each variable of type τ into an element of D_τ. Where g is such, the update $g[x := d]$ is $(g - \{(x, g(x))\}) \cup \{(x, d)\}$. Relative to a valuation, an assignment g and a world $i \in W$, each term ϕ of type τ receives an interpretation $[\phi]^{g,i} \in D_\tau$ as follows:

(4)
$$\begin{array}{rcl} [a]^{g,i} & = & f(a) \text{ for constant } a \in C_\tau \\ [x]^{g,i} & = & g(x) \text{ for variable } x \in V_\tau \\ [t]^{g,i} & = & \emptyset \\ [(\phi\ \psi)]^{g,i} & = & [\phi]^{g,i}([\psi]^{g,i}) \\ [\lambda x \phi]^{g,i} & = & d \mapsto [\phi]^{g[x:=d],i} \\ [{}^\vee\phi]^{g,i} & = & [\phi]^{g,i}(i) \\ [{}^\wedge\phi]^{g,i} & = & j \mapsto [\phi]^{g,j} \end{array}$$

In a term or subterm $\lambda x \phi$ (or ${}^\wedge\phi$), ϕ is the *scope* of λx (or ${}^\wedge$). An occurrence of a variable x in a term is called *free* if and only if it does not fall within the scope of any λx; otherwise it is *bound* (by the closest λx within the scope of which it falls). The result $\phi[\psi_1/x, \ldots, \psi_n/x_n]$ of substituting terms $\psi_1, \ldots, \psi_n$ (of types $\tau_1, \ldots, \tau_n$) for variables $x_1, \ldots, x_n$ (of types $\tau_1, \ldots, \tau_n$) in a term ϕ is the result of simultaneously replacing by $\psi_1, \ldots, \psi_n$ every free occurrence of $x_1, \ldots, x_n$ respectively in ϕ. We say that ψ is *free for* x *in* ϕ if and only if no variable in ψ becomes bound in $\phi[\psi/x]$. We say that a term is *modally closed* if and only if every occurrence of ${}^\vee$ occurs within the scope of an ${}^\wedge$. A modally closed term is denotationally invariant across worlds. We say that a term ψ is *modally free for* x *in* ϕ if and only if either ψ is modally closed, or no free occurrence of x in ϕ is within the scope of an ${}^\wedge$. The laws of conversion in Figure 1 obtain.

$$\begin{array}{rcll} \lambda x\phi & = & \lambda y(\phi[y/x]) & \text{if } y \text{ is not free in } \phi \text{ and is free for } x \text{ in } \phi \\ & \textit{\alpha-conversion} & & \end{array}$$

$$\begin{array}{rcll} (\lambda x\phi\ \psi) & = & \phi[\psi/x] & \text{if } \psi \text{ is free for } x \text{ in } \phi \text{ and is modally free for } x \text{ in } \phi \\ {}^{\vee\wedge}\phi & = & \phi & \\ & \textit{\beta-conversion} & & \end{array}$$

$$\begin{array}{rcll} \lambda x(\phi\ x) & = & \phi & \text{if } x \text{ is not free in } \phi \\ {}^{\wedge\vee}\phi & = & \phi & \text{if } \phi \text{ is modally closed} \\ & \textit{\eta-conversion} & & \end{array}$$

Figure 1: Semantic conversion laws

2.2 Calculus

The “displacement” calculus of Morrill, Valentín and Fadda (2011) refounds categorial calculus accommodating displacement, or syntactic and semantic mismatch, a key issue in grammar. But as observed by Ruth Kempson (p.c.) it realises displacement without displacement (disorder turns out to be order again), so that we may more revealingly speak of *placement* calculus.

The placement calculus retains the setwise concatenation $\bullet$ and its left and right residuals $\backslash$ and $/$ of the Lambek calculus, which operate in a horizontal dimension, in a context in which there is also setwise wrap $\odot$ and its upper and lower residuals $\uparrow$ and $\downarrow$, which operate in a vertical dimension. Control of the partiality of the wrapping operations requires a sorting discipline on the types (0 = continuous; > 0 = discontinuous) and a novel sequent calculus in the configurations of which continuous types are leaves but discontinuous types are mothers. In this sense the placement calculus is not an extension of the Lambek calculus, but an embedding of it in a new context. This context has both horizontal and vertical dimensions and what appears to involve displacement in one, horizontal, dimension is no longer displacement when the second, vertical, dimension is added, but simply placement.[1]

Taking as a basis the placement calculus, types are sorted according to the number of points of discontinuity or placeholders their expressions contain. Here we use product-free placement calculus together with a modality for intensionality (Morrill 1990), the limited contraction operator of Jäger (2005) for anaphora, and a (succedent position only) difference operator which is a slight adaptation of the negation as failure of Morrill and Valentín (2010a); see Morrill and Valentín (2013). We define types $\mathcal{F}_i^p$ of sort $i \in \{0, 1, \ldots\}$ and polarity $p \in \{\bullet, \circ\}$ (input and output); where p is a polarity, $\overline{p}$ is the opposite polarity. On the basis of atomic types this definition is as follows (together with the homomorphic type map T from syntactic types to semantic types), where the subscript $k = +$ or $-$:[2]

$$\begin{array}{llllcll}
(5) & \mathcal{F}_j^p & ::= & \mathcal{F}_i^{\overline{p}}\backslash\mathcal{F}_{i+j}^p & T(A\backslash C) & = & T(A) \to T(C) & \text{left concatenation} \\
& \mathcal{F}_i^p & ::= & \mathcal{F}_{i+j}^p/\mathcal{F}_j^{\overline{p}} & T(C/B) & = & T(B) \to T(C) & \text{right concatenation} \\
& \mathcal{F}_0^p & ::= & I & T(I) & = & \top & \text{concatenation unit} \\
& \mathcal{F}_j^p & ::= & \mathcal{F}_{i+1}^{\overline{p}}\downarrow_k\mathcal{F}_{i+j}^p & T(A\downarrow_k C) & = & T(A) \to T(C) & \text{wrapping infix} \\
& \mathcal{F}_{i+1}^p & ::= & \mathcal{F}_{i+j}^p\uparrow_k\mathcal{F}_j^{\overline{p}} & T(C\uparrow_k B) & = & T(B) \to T(C) & \text{wrapping circumfix} \\
& \mathcal{F}_1^p & ::= & J & T(J) & = & \top & \text{wrapping unit} \\
& \mathcal{F}_i^p & ::= & \Box\mathcal{F}_i^p & T(\Box A) & = & \mathbf{L}A & \text{semantic modality} \\
& \mathcal{F}_i^p & ::= & \mathcal{F}_i^p|\mathcal{F}_j^{\overline{p}} & T(B|A) & = & T(A) \to T(B) & \text{limited contraction} \\
& \mathcal{F}_i^\circ & ::= & \mathcal{F}_i^\circ - \mathcal{F}_i^\circ & T(A - B) & = & T(A) & \text{difference}
\end{array}$$

Where A is a type, sA is its sort.

[1]Naturally this move strictly extends the context-free recognizing power of the Lambek calculus, see Morrill and Valentín (2010b).

[2]The polarities are employed to restrict the occurrences of the difference operator to output/succedent positions.

The set $\mathcal{O}$ of *configurations* is defined as follows, where $\mathtt{1}$ is the metalinguistic placeholder:

(6) $\mathcal{O} ::= \Lambda \mid \mathtt{1} \mid \mathcal{F}_0{}^\bullet \mid \mathcal{F}_{i+1}{}^\bullet\{\underbrace{\mathcal{O} : \ldots : \mathcal{O}}_{i+1\ \mathcal{O}\text{'s}}\} \mid \mathcal{O}, \mathcal{O}$

$A\{\Gamma_1 : \ldots : \Gamma_n\}$ interpreted syntactically is formed by strings $s_0{+}t_1{+}s_1{+}\cdots{+}\ s_{n-1}{+}t_n{+}s_n$ where $s_0{+}1{+}s_1{+}\cdots{+}s_{n-1}{+}1{+}s_n \in A$ and $t_1 \in \Gamma_1, \ldots, t_n \in \Gamma_n$. The *figure* or *vector* $\overrightarrow{A}$ of a type A is defined by:

(7) $\overrightarrow{A} = \begin{cases} A & \text{if the sort of } A \text{ is } 0 \\ A\{\underbrace{\mathtt{1} : \ldots : \mathtt{1}}_{sA\ \mathtt{1}\text{'s}}\} & \text{if the sort of } A \text{ is greater than } 0 \end{cases}$

The sort of a configuration is the number of metalinguistic placeholders it contains. Where Δ and Γ are configurations and Δ is of sort at least one , $\Delta|_+\Gamma$ signifies the configuration which is the result of replacing the leftmost metalinguistic placeholder in Δ by Γ, and $\Delta|_-\Gamma$ signifies the configuration which is the result of replacing the rightmost metalinguistic placeholder in Δ by Γ. Where Δ is a configuration of sort i and $\Gamma_1, \ldots, \Gamma_i$ are configurations, the *fold* $\Delta \otimes \langle\Gamma_1, \ldots, \Gamma_i\rangle$ is the result of simultaneously replacing the successive placeholders in Δ by $\Gamma_1, \ldots, \Gamma_i$ respectively. The *distinguished hyperoccurrence* notation $\Delta\langle\Gamma\rangle$ abbreviates $\Delta_0(\Gamma \otimes \langle\Delta_1, \ldots, \Delta_i\rangle)$. Multiple distinguished hyperoccurrences will be separated by semicolons within the angle brackets. A *hypersequent* $\Gamma \Rightarrow A$ comprises an antecedent configuration Γ of sort i and a succedent type A belonging to $\mathcal{F}_i^\circ$. The semantically labelled sequent calculus for our categorial logic is given in Figure 2, where $k \in \{+, -\}$, and $\Box\Gamma$ signifies a configuration all the types of which are $\Box$-ed outermost.

3 Grammar

We structure atomic types N for name or (referring) nominal and CN for common noun or count noun with feature terms for gender for which there are feature constants (lower case) m (masculine), f (feminine) and n (neuter) and a denumerably infinite supply of feature variables. Feature variables, in alphabet initial upper case, are understood as being universally quantified outermost in types and thus undergo unification in the usual way. Other atomic types are S for statement or (declarative) sentence and CP for complementizer phrase. All these atomic types are of sort 0. Our lexicon for the Montague fragment is as shown in Figure 3; henceforth we omit the subscript $+$ for leftmost wrap on connectives.

4 Analyses

This section annotates with commentary the output of the Prolog parser/theorem prover CatLog (Morrill 2012) for the categorial logic and Montague fragment lexicon here. The program implements directly Cut-free backward chaining sequent proof search, which is terminating since the rules can be applied in only a finite number of ways matching a sequent against the conclusion and reading backwards to create premise subgoals, and premises always contain fewer connective occurrences than their conclusion. Derivational equivalence, or spurious ambiguity, is handled by sequent proof normalization (Morrill 2011), equivalent to focusing; the search space is further pruned according to count invariance (Valentín, Serret and Morrill 2013).

For reasons of space we consider only the analyses of the first half of Chapter 7 of Dowty, Wall and Peters (1981) (henceforth DWP); for the second half see Morrill (in press). The first sentence for which DWP provides an analysis tree is (we include their numbering):

(8) (7-16) **every**+**man**+**talks** : S

This involves a quantifier phrase in subject position. Lookup in our lexicon yields the following semantically labelled sequent:

$$\frac{}{\overrightarrow{A}: x \Rightarrow A: x}\, id$$

$$\frac{\Gamma \Rightarrow A:\phi \qquad \Delta\langle\overrightarrow{C}:z\rangle \Rightarrow D:\omega}{\Delta\langle\Gamma, \overrightarrow{A\backslash C}:y\rangle \Rightarrow D:\omega[(y\ \phi)/z]}\,\backslash L \qquad \frac{\overrightarrow{A}:x,\Gamma \Rightarrow C:\chi}{\Gamma\Rightarrow A\backslash C:\lambda x\chi}\,\backslash R$$

$$\frac{\Gamma \Rightarrow B:\psi \qquad \Delta\langle\overrightarrow{C}:z\rangle \Rightarrow D:\omega}{\Delta\langle\overrightarrow{C/B}:x, \Gamma\rangle \Rightarrow D:\omega[(x\ \psi)/z]}\,/L \qquad \frac{\Gamma, \overrightarrow{B}:y \Rightarrow C:\chi}{\Gamma\Rightarrow C/B:\lambda y\chi}\,/R$$

$$\frac{\Delta\langle\Lambda\rangle \Rightarrow A:\phi}{\Delta\langle\overrightarrow{I}:t\rangle \Rightarrow A:\phi}\,IL \qquad \frac{}{\Lambda \Rightarrow I:t}\,IR$$

$$\frac{\Gamma \Rightarrow A:\phi \qquad \Delta\langle\overrightarrow{C}:z\rangle \Rightarrow D:\omega}{\Delta\langle\Gamma|_k\overrightarrow{A{\downarrow_k}C}:y\rangle \Rightarrow D:\omega[(y\ \phi)/z]}\,{\downarrow_k}L \qquad \frac{\overrightarrow{A}:x|_k\Gamma \Rightarrow C:\chi}{\Gamma\Rightarrow A{\downarrow_k}C:\lambda x\chi}\,{\downarrow_k}R$$

$$\frac{\Gamma \Rightarrow B:\psi \qquad \Delta\langle\overrightarrow{C}:z\rangle \Rightarrow D:\omega}{\Delta\langle\overrightarrow{C{\uparrow_k}B}:x|_k\Gamma\rangle \Rightarrow D:\omega[(x\ \psi)/z]}\,{\uparrow_k}L \qquad \frac{\Gamma|_k\overrightarrow{B}:y \Rightarrow C:\chi}{\Gamma\Rightarrow C{\uparrow_k}B:\lambda y\chi}\,{\uparrow_k}R$$

$$\frac{\Delta\langle\mathtt{1}\rangle \Rightarrow A}{\Delta\langle\overrightarrow{J}:t\rangle \Rightarrow A}\,JL \qquad \frac{}{\mathtt{1} \Rightarrow J:t}\,JR$$

$$\frac{\Gamma\langle\overrightarrow{A}:x\rangle \Rightarrow B:\psi}{\Gamma\langle\overrightarrow{\Box A}:z\rangle \Rightarrow B:\psi[{}^\vee z/x]}\,\Box L \qquad \frac{\Box\Gamma \Rightarrow A:\phi}{\Box\Gamma \Rightarrow \Box A:{}^\wedge\phi}\,\Box R$$

$$\frac{\Gamma \Rightarrow A:\phi \qquad \Delta\langle\overrightarrow{A}:x;\overrightarrow{B}:y\rangle \Rightarrow D:\omega}{\Delta\langle\Gamma;\overrightarrow{B|A}:z\rangle \Rightarrow D:\omega[\phi/x,(z\ \phi)/y]}\,|L$$

$$\frac{\Gamma\langle\overrightarrow{B_0}:y_0;\ldots;\overrightarrow{B_n}:y_n\rangle \Rightarrow D:\omega}{\Gamma\langle\overrightarrow{B_0|A}:z_0;\ldots;\overrightarrow{B_n|A}:z_n\rangle \Rightarrow D|A:\lambda x\omega[(z_0\ x)/y_0,\ldots,(z_n\ x)/y_n]}\,|R$$

$$\frac{\Gamma \Rightarrow A:\phi \qquad \not\vdash \Gamma \Rightarrow B:\_}{\Gamma \Rightarrow A-B:\phi}\,-R$$

Figure 2: Semantically labelled sequent calculus for the categorial logic

a : $\Box(((S{\uparrow}\Box NA){\downarrow}S)/CNA) : \hat{}\lambda B\lambda C\exists D[(B\ D) \wedge (C\ \hat{}D)]$

and : $\Box((S\backslash S)/S) : \hat{}\lambda A\lambda B[B \wedge A]$

and : $\Box(((NA\backslash S)\backslash(NA\backslash S))/(NA\backslash S)) : \hat{}\lambda B\lambda C\lambda D[(C\ D) \wedge (B\ D)]$

believes : $\Box((NA\backslash S)/CP) : \mathit{believe}$

bill : $\Box Nm : \hat{}b$

catch : $\Box((NA\backslash S)/NB) : \mathit{catch}$

doesnt : $\Box((NA\backslash S)/(NA\backslash S)) : \hat{}\lambda B\lambda C\neg(B\ C)$

eat : $\Box((NA\backslash S)/NB) : \mathit{eat}$

every : $\Box(((S{\uparrow}NA){\downarrow}S)/CNA) : \hat{}\lambda B\lambda C\forall D[(B\ D) \to (C\ D)]$

finds : $\Box((NA\backslash S)/NB) : \mathit{finds}$

fish : $\Box CNn : \mathit{fish}$

he : $\Box((\Box S|Nm)/\Box(Nm\backslash S)) : \hat{}\lambda A\lambda B\hat{}(\check{}A\ B)$

her : $\Box(\Box((S{\uparrow}Nf) - (J\bullet(Nf\backslash S))){\downarrow}(\Box S|Nf)) : \hat{}\lambda A\lambda B\hat{}(\check{}A\ B)$

her : $\Box(((((S{\uparrow}Nf) - (J\bullet(Nf\backslash S))){\uparrow}\Box Nf) - (J\bullet((Nf\backslash S){\uparrow}Nf))){\downarrow_{\_}}(S{\uparrow}\Box Nf)) : \hat{}\lambda A\lambda B((A\ B)\ \check{}B)$

in : $\Box(((NA\backslash S)\backslash(NA\backslash S))/NB) : \hat{}\lambda C\lambda D\lambda E((\check{}\mathit{in}\ C)\ (D\ E))$

is : $\Box((NA\backslash S)/NB) : \hat{}\lambda C\lambda D[D = C]$

it : $\Box(\Box(S{\uparrow}Nn){\downarrow}(\Box S|Nn)) : \hat{}\lambda A\lambda B\hat{}(\check{}A\ B)$

it : $\Box(((((S{\uparrow}Nn) - (J\bullet(Nn\backslash S))){\uparrow}\Box Nn) - (J\bullet((Nn\backslash S){\uparrow}Nn))){\downarrow_{\_}}(S{\uparrow}\Box Nn)) : \hat{}\lambda A\lambda B((A\ B)\ \check{}B)$

john : $\Box Nm : \hat{}j$

loses : $\Box((NA\backslash S)/NB) : \mathit{loses}$

loves : $\Box((NA\backslash S)/NB) : \mathit{loves}$

man : $\Box CNm : \mathit{man}$

necessarily : $\Box(S/\Box S) : \hat{}\mathit{nec}$

or : $\Box((S\backslash S)/S) : \hat{}\lambda A\lambda B[B \vee A]$

or : $\Box(((NA\backslash S)\backslash(NA\backslash S))/(NA\backslash S)) : \hat{}\lambda B\lambda C\lambda D[(C\ D) \vee (B\ D)]$

park : $\Box CNn : \mathit{park}$

seeks : $\Box((NA\backslash S)/\Box(((NB\backslash S)/NC)\backslash(NB\backslash S))) : \hat{}\lambda D\lambda E((\mathit{tries}\ \hat{}((\check{}D\ \mathit{find})\ E))\ E)$

she : $\Box((\Box S|Nf)/\Box(Nf\backslash S)) : \hat{}\lambda A\lambda B\hat{}(\check{}A\ B)$

slowly : $\Box(\Box(NA\backslash S)\backslash(NA\backslash S)) : \mathit{slowly}$

such+that : $\Box((CNA\backslash CNA)/(S|NA)) : \hat{}\lambda B\lambda C\lambda D[(C\ D) \wedge (B\ D)]$

talks : $\Box(NA\backslash S) : \mathit{talk}$

that : $\Box(CP/\Box S) : \hat{}\lambda AA$

the : $\Box(NA/CNA) : \mathit{the}$

to : $\Box((NA\backslash S)/(NA\backslash S)) : \hat{}\lambda BB$

tries : $\Box((NA\backslash S)/\Box(NA\backslash S)) : \hat{}\lambda B\lambda C((\check{}\mathit{tries}\ \hat{}(\check{}B\ C))\ C)$

unicorn : $\Box CNn : \mathit{unicorn}$

walk : $\Box(NA\backslash S) : \mathit{walk}$

walks : $\Box(NA\backslash S) : \mathit{walk}$

woman : $\Box CNf : \mathit{woman}$

Figure 3: The Montague fragment categorial lexicon

$$
\begin{prooftree}
\AxiomC{}
\UnaryInfC{$CNm \Rightarrow CNm$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box CNm \Rightarrow CNm$}
\AxiomC{}
\UnaryInfC{$Nm \Rightarrow Nm$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$Nm, Nm\backslash S \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$Nm, \Box(Nm\backslash S) \Rightarrow S$}
\RightLabel{$\uparrow R$}
\UnaryInfC{$1, \Box(Nm\backslash S) \Rightarrow S{\uparrow}Nm$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\downarrow L$}
\BinaryInfC{$(S{\uparrow}Nm){\downarrow}S, \Box(Nm\backslash S) \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$((S{\uparrow}Nm){\downarrow}S)/CNm, \Box CNm, \Box(Nm\backslash S) \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(((S{\uparrow}Nm){\downarrow}S)/CNm), \Box CNm, \Box(Nm\backslash S) \Rightarrow S$}
\end{prooftree}
$$

Figure 4: Derivation for *Every man talks*

$$
\begin{prooftree}
\AxiomC{}
\UnaryInfC{$CNn \Rightarrow CNn$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box CNn \Rightarrow CNn$}
\AxiomC{}
\UnaryInfC{$Nn \Rightarrow Nn$}
\RightLabel{$/L$}
\BinaryInfC{$Nn/CNn, \Box CNn \Rightarrow Nn$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(Nn/CNn), \Box CNn \Rightarrow Nn$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$\Box(Nn/CNn), \Box CNn, Nn\backslash S \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(Nn/CNn), \Box CNn, \Box(Nn\backslash S) \Rightarrow S$}
\end{prooftree}
$$

Figure 5: Derivation for *The fish walks*

(9) $\Box(((S{\uparrow}NA){\downarrow}S)/CNA) : \hat{}\lambda B \lambda C \forall D[(B\ D) \to (C\ D)], \Box CNm : man,$
$\Box(NE\backslash S) : talk \ \Rightarrow\ S$

Here and always lexical types are modalized outermost because lexical meanings are intensions. Within its modality the type for the quantifier is a functor seeking a count noun to its right; the feature variable A selects the gender value. This yields a generalized quantifier type which will infix at the result of extracting a nominal, simulating Montague's rule of term insertion or quantifying in S14. The derivation is given in Figure 4. This yields the required semantics:

(10) $\forall C[(\check{}\,man\ C) \to (\check{}\,talk\ C)]$

Montague's Intensional Logic assigned nonlogical constants of type τ a denotation in the intension of τ and then interpreted a constant with respect to a world as its extension in that world. Our semantic representation language assigns constants denotations in their own type, so our semantic representations have explicit extensionalization of nonlogical constants.

The next example of DWP is:

(11) (7-19) **the+fish+walks** : S

Montague analysed the definite article as universal quantification with unicity but this does not reflect its presuppositional character. In our grammar we assume that since unicity is presupposed anyway, the definite article maps to a simple nominal. The result of lexical lookup is:

(12) $\Box(NA/CNA) : the, \Box CNn : fish, \Box(NB\backslash S) : walk \ \Rightarrow\ S$

This has the derivation in Figure 5. The derivation yields the semantics:

(13) $(\check{}\,walk\ (\check{}\,the\ \check{}\,fish))$

The next example involves subject quantification and verb phrase coordination:

(14) (7-32) **every+man+walks+or+talks** : S

Lexical lookup inserting the sentential coordinator yields the semantically labelled sequent:

(15) $\Box(((S\uparrow NA)\downarrow S)/CNA) : \hat{}\lambda B\lambda C\forall D[(B\ D) \rightarrow (C\ D)], \Box CNm : man,$
$\Box(NE\backslash S) : walk, \Box((S\backslash S)/S) : \hat{}\lambda F\lambda G[G \vee F], \Box(NH\backslash S) : talk \ \Rightarrow\ S$

This has no derivation. The correct lexical lookup, inserting the verb phrase coordinator, yields the semantically labelled sequent:

(16) $\Box(((S\uparrow NA)\downarrow S)/CNA) : \hat{}\lambda B\lambda C\forall D[(B\ D) \rightarrow (C\ D)], \Box CNm : man,$
$\Box(NE\backslash S) : walk, \Box(((NF\backslash S)\backslash(NF\backslash S))/(NF\backslash S)) :$
$\hat{}\lambda G\lambda H\lambda I[(H\ I) \vee (G\ I)], \Box(NJ\backslash S) : talk \ \Rightarrow\ S$

This has the derivation given in Figure 6. The derivation delivers semantics:

(17) $\forall C[(\check{}man\ C) \rightarrow [(\check{}walk\ C) \vee (\check{}talk\ C)]]$

The next example is:

(18) (7-34) **every+man+walks+or+every+man+talks** : S

Lexical lookup with the (correct) lexical insertion of the sentential coordinator produces the semantically labelled sequent:

(19) $\Box(((S\uparrow NA)\downarrow S)/CNA) : \hat{}\lambda B\lambda C\forall D[(B\ D) \rightarrow (C\ D)], \Box CNm : man,$
$\Box(NE\backslash S) : walk, \Box((S\backslash S)/S) : \hat{}\lambda F\lambda G[G\vee F], \Box(((S\uparrow NH)\downarrow S)/CNH) : \hat{}\lambda I\lambda J\forall K[(I\ K) \rightarrow$
$(J\ K)], \Box CNm : man, \Box(NL\backslash S) : talk \ \Rightarrow\ S$

It is enough for the quantifier phrases to each take scope within their conjunt and this is the derivation which we give in Figure 7. However the quantifier phrases can also term insert at the matrix level, and do so in either order, adding four other (synonomous) derivations. We omit these. The semantics assigned is:

(20) $[\forall I[(\check{}man\ I) \rightarrow (\check{}walk\ I)] \vee \forall E[(\check{}man\ E) \rightarrow (\check{}talk\ E)]]$

Lexical insertion of the (incorrect) verb phrase coordinator entry yields the semantically labelled sequent:

(21) $\Box(((S\uparrow NA)\downarrow S)/CNA) : \hat{}\lambda B\lambda C\forall D[(B\ D) \rightarrow (C\ D)], \Box CNm : man,$
$\Box(NE\backslash S) : walk, \Box(((NF\backslash S)\backslash(NF\backslash S))/(NF\backslash S)) :$
$\hat{}\lambda G\lambda H\lambda I[(H\ I) \vee (G\ I)], \Box(((S\uparrow NJ)\downarrow S)/CNJ) :$
$\hat{}\lambda K\lambda L\forall M[(K\ M) \rightarrow (L\ M)], \Box CNm : man, \Box(NN\backslash S) : talk \ \Rightarrow\ S$

This has no derivation.

The next example involves anaphora:

(22) (7-39) **a+woman+walks+and+she+talks** : S

Correct lexical lookup inserting the sentential coordinator type yields:

(23) $\Box(((S\uparrow\Box NA)\downarrow S)/CNA) : \hat{}\lambda B\lambda C\exists D[(B\ D) \wedge (C\ \hat{}D)], \Box CNf : woman,$
$\Box(NE\backslash S) : walk, \Box((S\backslash S)/S) : \hat{}\lambda F\lambda G[G\wedge F], \Box((\Box S|Nf)/\Box(Nf\backslash S)) : \hat{}\lambda H\lambda I\hat{}(\check{}H\ I), \Box(NJ\backslash S) :$
$talk \ \Rightarrow\ S$

Our lexical type assignment to the nominative pronoun ensures that it applies to the right to a verb phrase, i.e. that it occupies subject position. The limited contraction type constructor of Jäger (2005) is used to create anaphoric dependency. There is the derivation given in Figure 8 where the treatments of anaphora and quantification (and coordination) interact. This correctly yields the semantics:

$$
\begin{prooftree}
\AxiomC{}
\UnaryInfC{$CNm \Rightarrow CNm$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box CNm \Rightarrow CNm$}
\AxiomC{}
\UnaryInfC{$Nm \Rightarrow Nm$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$Nm, Nm\backslash S \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$Nm, \Box(Nm\backslash S) \Rightarrow S$}
\RightLabel{$\backslash R$}
\UnaryInfC{$\Box(Nm\backslash S) \Rightarrow Nm\backslash S$}
\AxiomC{}
\UnaryInfC{$Nm \Rightarrow Nm$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$Nm, Nm\backslash S \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$Nm, \Box(Nm\backslash S) \Rightarrow S$}
\RightLabel{$\backslash R$}
\UnaryInfC{$\Box(Nm\backslash S) \Rightarrow Nm\backslash S$}
\AxiomC{}
\UnaryInfC{$Nm \Rightarrow Nm$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$Nm, Nm\backslash S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$Nm, \Box(Nm\backslash S), (Nm\backslash S)\backslash(Nm\backslash S) \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$Nm, \Box(Nm\backslash S), ((Nm\backslash S)\backslash(Nm\backslash S))/(Nm\backslash S), \Box(Nm\backslash S) \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$Nm, \Box(Nm\backslash S), \Box(((Nm\backslash S)\backslash(Nm\backslash S))/(Nm\backslash S)), \Box(Nm\backslash S) \Rightarrow S$}
\RightLabel{$\uparrow R$}
\UnaryInfC{$1, \Box(Nm\backslash S), \Box(((Nm\backslash S)\backslash(Nm\backslash S))/(Nm\backslash S)), \Box(Nm\backslash S) \Rightarrow S{\uparrow}Nm$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\downarrow L$}
\BinaryInfC{$(S{\uparrow}Nm){\downarrow}S, \Box(Nm\backslash S), \Box(((Nm\backslash S)\backslash(Nm\backslash S))/(Nm\backslash S)), \Box(Nm\backslash S) \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$((S{\uparrow}Nm){\downarrow}S)/CNm, \Box CNm, \Box(Nm\backslash S), \Box(((Nm\backslash S)\backslash(Nm\backslash S))/(Nm\backslash S)), \Box(Nm\backslash S) \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(((S{\uparrow}Nm){\downarrow}S)/CNm), \Box CNm, \Box(Nm\backslash S), \Box(((Nm\backslash S)\backslash(Nm\backslash S))/(Nm\backslash S)), \Box(Nm\backslash S) \Rightarrow S$}
\end{prooftree}
$$

Figure 6: Derivation for *Every man walks or talks*

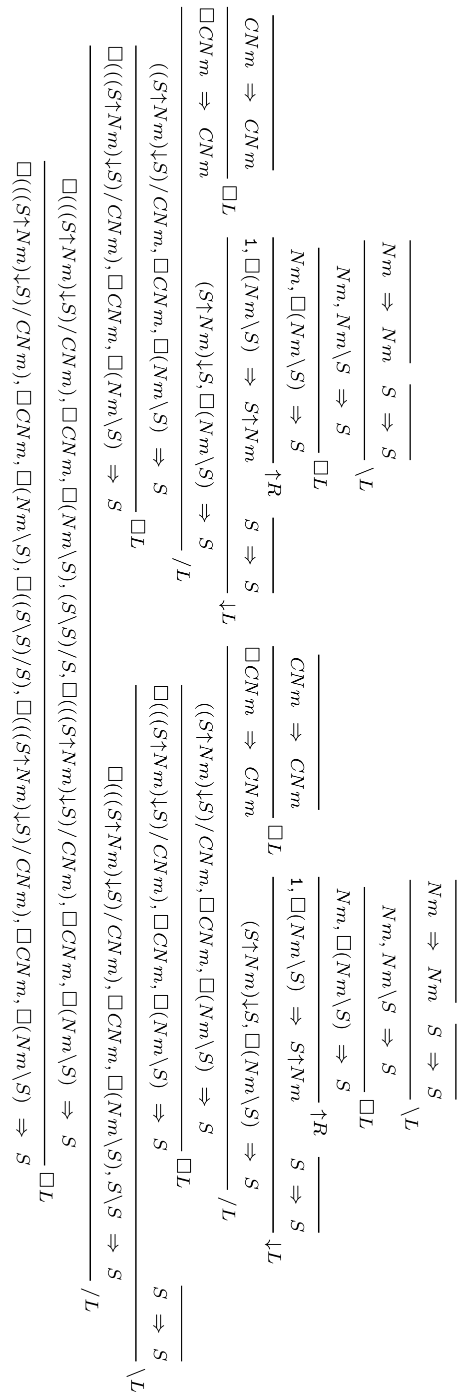

Figure 7: Derivation for *Every man walks or every man talks*

$$\dfrac{\overline{Nf \Rightarrow Nf} \quad \overline{S \Rightarrow S}}{Nf, Nf\backslash S \Rightarrow S}\,\backslash L$$

$$\dfrac{Nf, Nf\backslash S \Rightarrow S}{Nf, \Box(Nf\backslash S) \Rightarrow S}\,\Box L$$

$$\dfrac{Nf, \Box(Nf\backslash S) \Rightarrow S}{\Box(Nf\backslash S) \Rightarrow Nf\backslash S}\,\backslash R$$

$$\dfrac{\Box(Nf\backslash S) \Rightarrow Nf\backslash S}{\Box(Nf\backslash S) \Rightarrow \Box(Nf\backslash S)}\,\Box R$$

$$\dfrac{\overline{Nf \Rightarrow Nf}}{\Box Nf \Rightarrow Nf}\,\Box L$$

$$\dfrac{\overline{S \Rightarrow S}}{\Box S \Rightarrow S}\,\Box L$$

$$\dfrac{\overline{Nf \Rightarrow Nf} \quad \overline{S \Rightarrow S}}{Nf, Nf\backslash S \Rightarrow S}\,\backslash L$$

$$\dfrac{Nf, Nf\backslash S \Rightarrow S}{Nf, \Box(Nf\backslash S) \Rightarrow S}\,\Box L$$

$$\dfrac{Nf, \Box(Nf\backslash S) \Rightarrow S \quad \overline{S \Rightarrow S}}{Nf, \Box(Nf\backslash S), S\backslash S \Rightarrow S}\,\backslash L$$

$$\dfrac{\Box S \Rightarrow S \quad Nf, \Box(Nf\backslash S), S\backslash S \Rightarrow S}{Nf, \Box(Nf\backslash S), (S\backslash S)/S, \Box S \Rightarrow S}\,/L$$

$$\dfrac{Nf, \Box(Nf\backslash S), (S\backslash S)/S, \Box S \Rightarrow S}{Nf, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box S \Rightarrow S}\,\Box L$$

$$\dfrac{\Box Nf \Rightarrow Nf \quad Nf, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box S \Rightarrow S}{\Box Nf, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box S|Nf \Rightarrow S}\,|L$$

$$\dfrac{\Box(Nf\backslash S) \Rightarrow \Box(Nf\backslash S) \quad \Box Nf, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box S|Nf \Rightarrow S}{\Box Nf, \Box(Nf\backslash S), \Box((S\backslash S)/S), (\Box S|Nf)/\Box(Nf\backslash S), \Box(Nf\backslash S) \Rightarrow S}\,/L$$

$$\dfrac{\Box Nf, \Box(Nf\backslash S), \Box((S\backslash S)/S), (\Box S|Nf)/\Box(Nf\backslash S), \Box(Nf\backslash S) \Rightarrow S}{\Box Nf, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box((\Box S|Nf)/\Box(Nf\backslash S)), \Box(Nf\backslash S) \Rightarrow S}\,\Box L$$

$$\dfrac{\Box Nf, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box((\Box S|Nf)/\Box(Nf\backslash S)), \Box(Nf\backslash S) \Rightarrow S}{\mathsf{1}, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box((\Box S|Nf)/\Box(Nf\backslash S)), \Box(Nf\backslash S) \Rightarrow S{\uparrow}\Box Nf}\,{\uparrow}R$$

$$\dfrac{\mathsf{1}, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box((\Box S|Nf)/\Box(Nf\backslash S)), \Box(Nf\backslash S) \Rightarrow S{\uparrow}\Box Nf \quad \overline{S \Rightarrow S}}{(S{\uparrow}\Box Nf){\downarrow}S, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box((\Box S|Nf)/\Box(Nf\backslash S)), \Box(Nf\backslash S) \Rightarrow S}\,{\downarrow}L$$

$$\dfrac{\overline{CNf \Rightarrow CNf}}{\Box CNf \Rightarrow CNf}\,\Box L$$

$$\dfrac{\Box CNf \Rightarrow CNf \quad (S{\uparrow}\Box Nf){\downarrow}S, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box((\Box S|Nf)/\Box(Nf\backslash S)), \Box(Nf\backslash S) \Rightarrow S}{((S{\uparrow}\Box Nf){\downarrow}S)/CNf, \Box CNf, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box((\Box S|Nf)/\Box(Nf\backslash S)), \Box(Nf\backslash S) \Rightarrow S}\,/L$$

$$\dfrac{((S{\uparrow}\Box Nf){\downarrow}S)/CNf, \Box CNf, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box((\Box S|Nf)/\Box(Nf\backslash S)), \Box(Nf\backslash S) \Rightarrow S}{\Box(((S{\uparrow}\Box Nf){\downarrow}S)/CNf), \Box CNf, \Box(Nf\backslash S), \Box((S\backslash S)/S), \Box((\Box S|Nf)/\Box(Nf\backslash S)), \Box(Nf\backslash S) \Rightarrow S}\,\Box L$$

Figure 8: Derivation for *A woman walks and she talks*

(24) $\exists C[(\check{}woman\ C) \wedge [(\check{}walk\ C) \wedge (\check{}talk\ C)]]$

Lexical lookup incorrectly inserting the verb phrase coordinator assignment yields a sequent for which there is no derivation.

The next analyses of DWP are for the de re or specific versus de dicto or nonspecific ambiguity of:

(25) (7-43, 7-45) **john+believes+that+a+fish+walks** : S

On Montague's account the indefinite quantifier phrase can quantify in at the matrix level yielding the de re reading in which the propositional attitude verb is within the scope of the existential quantification (John's belief is directed towards a specific fish) or it can quantify in at the level of the subordinate clause in which case the existential quantification is within the scope of the propositional attitude verb (John has no specific fish in mind). Our grammar conserves this account. Lexical lookup yields the semantically labelled sequent:

(26) $\Box Nm : \hat{}j, \Box((NA\backslash S)/CP) : \mathit{believe}, \Box(CP/\Box S) : \hat{}\lambda BB,$
$\Box(((S\uparrow\Box NC)\downarrow S)/CNC) : \hat{}\lambda D\lambda E\exists F[(D\ F) \wedge (E\ \hat{}F)], \Box CNn : \mathit{fish},$
$\Box(NG\backslash S) : \mathit{walk} \Rightarrow S$

In Montague grammar the requirement that all term phrases have the same semantic type necessitates type raising proper names to the same type as quantifier phrases; and a meaning postulate is required to make them rigid designators (i.e. denote the same individual in all worlds). Note how in type logical grammar a proper name can be assigned its lower type, and our lexical semantics codes that it is intensional, but a rigid designator. The de re derivation is given in Figure 9. This delivers semantics:

(27) $\exists C[(\check{}fish\ C) \wedge ((\check{}believe\ \hat{}(\check{}walk\ C))\ j)]$

Observe that the modalization of the sentence complementized translates into an intensionalized formula, i.e. a proposition, for the propositional attitude verb. The $\Box R$ inference in the de re derivation depends on the hypothetical subtype introduced by the indefinite being modal. By contrast, in our type logical grammar the corresponding subtype of *every* is not modal, limiting its quantification to local scope (something Montague did not capture). The de dicto derivation is given in Figure 10. This delivers semantics:

(28) $((\check{}believe\ \hat{}\exists D[(\check{}fish\ D) \wedge (\check{}walk\ D)])\ j)$

The next example combines the previous ambiguity with alternative quantifier scopings at the matrix level; a total of three readings:

(29) (7-48, 7-49, 7-52) **every+man+believes+that+a+fish+walks** : S

Lexical lookup yields the semantically labelled sequent:

(30) $\Box(((S\uparrow NA)\downarrow S)/CNA) : \hat{}\lambda B\lambda C\forall D[(B\ D) \rightarrow (C\ D)], \Box CNm : \mathit{man},$
$\Box((NE\backslash S)/CP) : \mathit{believe}, \Box(CP/\Box S) : \hat{}\lambda FF, \Box(((S\uparrow\Box NG)\downarrow S)/CNG) : \hat{}\lambda H\lambda I\exists J[(H\ J) \wedge$
$(I\ \hat{}J)], \Box CNn : \mathit{fish}, \Box(NK\backslash S) : \mathit{walk} \Rightarrow S$

A first derivation, in which the existential quantifies in at the widest level, is given in Figure 11. This delivers semantics:

(31) $\exists C[(\check{}fish\ C) \wedge \forall G[(\check{}man\ G) \rightarrow ((\check{}believe\ \hat{}(\check{}walk\ C))\ G)]]$

A second derivation, in which the existential quantifies in outside of the propositional attitude verb but still within the universal, is given in Figure 12. This delivers semantics:

(32) $\forall C[(\check{}man\ C) \rightarrow \exists G[(\check{}fish\ G) \wedge ((\check{}believe\ \hat{}(\check{}walk\ G))\ C)]]$

The third derivation, in which the existential takes narrowest scope, in given in Figure 13. This delivers semantics:

$$
\dfrac{\dfrac{\dfrac{}{CNn \Rightarrow CNn}}{\Box CNn \Rightarrow CNn}\,\Box L
\qquad
\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{}{Nn \Rightarrow Nn}}{\Box Nn \Rightarrow Nn}\,\Box L \quad \dfrac{}{S \Rightarrow S}}{\Box Nn, Nn\backslash S \Rightarrow S}\,\backslash L}{\Box Nn, \Box(Nn\backslash S) \Rightarrow S}\,\Box L}{\Box Nn, \Box(Nn\backslash S) \Rightarrow \Box S}\,\Box R \quad \dfrac{}{CP \Rightarrow CP}}{CP/\Box S, \Box Nn, \Box(Nn\backslash S) \Rightarrow CP}\,/L}{\Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \Rightarrow CP}\,\Box L
\quad
\dfrac{\dfrac{\dfrac{}{Nm \Rightarrow Nm}}{\Box Nm \Rightarrow Nm}\,\Box L \quad \dfrac{}{S \Rightarrow S}}{\Box Nm, Nm\backslash S \Rightarrow S}\,\backslash L}{\Box Nm, (Nm\backslash S)/CP, \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \Rightarrow S}\,/L}{\Box Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \Rightarrow S}\,\Box L}{\Box Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), 1, \Box(Nn\backslash S) \Rightarrow S{\uparrow}\Box Nn}\,{\uparrow}R
\quad \dfrac{}{S \Rightarrow S}}{\Box Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), (S{\uparrow}\Box Nn){\downarrow}S, \Box(Nn\backslash S) \Rightarrow S}\,{\downarrow}L}{\dfrac{\Box Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), ((S{\uparrow}\Box Nn){\downarrow}S)/CNn, \Box CNn, \Box(Nn\backslash S) \Rightarrow S}{\Box Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \Rightarrow S}\,\Box L}\,/L
$$

Figure 9: De re derivation for *John believes that a fish walks*

$$\frac{}{Nn \;\Rightarrow\; Nn}$$

$$\frac{Nn \;\Rightarrow\; Nn}{\Box Nn \;\Rightarrow\; Nn}\,\Box L \qquad \frac{}{S \;\Rightarrow\; S}$$

$$\frac{\Box Nn \;\Rightarrow\; Nn \qquad S \;\Rightarrow\; S}{\Box Nn, Nn\backslash S \;\Rightarrow\; S}\,\backslash L$$

$$\frac{\Box Nn, Nn\backslash S \;\Rightarrow\; S}{\Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,\Box L$$

$$\frac{\Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; S}{1, \Box(Nn\backslash S) \;\Rightarrow\; S{\uparrow}\Box Nn}\,{\uparrow}R$$

$$\frac{1, \Box(Nn\backslash S) \;\Rightarrow\; S{\uparrow}\Box Nn \qquad \overline{S \;\Rightarrow\; S}}{(S{\uparrow}\Box Nn){\downarrow}S, \Box(Nn\backslash S) \;\Rightarrow\; S}\,{\downarrow}L$$

$$\frac{\overline{CNn \;\Rightarrow\; CNn}}{\Box CNn \;\Rightarrow\; CNn}\,\Box L$$

$$\frac{\Box CNn \;\Rightarrow\; CNn \qquad (S{\uparrow}\Box Nn){\downarrow}S, \Box(Nn\backslash S) \;\Rightarrow\; S}{((S{\uparrow}\Box Nn){\downarrow}S)/CNn, \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,/L$$

$$\frac{((S{\uparrow}\Box Nn){\downarrow}S)/CNn, \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}{\Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,\Box L$$

$$\frac{\Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}{\Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; \Box S}\,\Box R$$

$$\frac{\Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; \Box S \qquad \overline{CP \;\Rightarrow\; CP}}{CP/\Box S, \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; CP}\,/L$$

$$\frac{CP/\Box S, \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; CP}{\Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; CP}\,\Box L$$

$$\frac{\overline{Nm \;\Rightarrow\; Nm}}{\Box Nm \;\Rightarrow\; Nm}\,\Box L \qquad \frac{}{S \;\Rightarrow\; S}$$

$$\frac{\Box Nm \;\Rightarrow\; Nm \qquad S \;\Rightarrow\; S}{\Box Nm, Nm\backslash S \;\Rightarrow\; S}\,\backslash L$$

$$\frac{\Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; CP \qquad \Box Nm, Nm\backslash S \;\Rightarrow\; S}{\Box Nm, (Nm\backslash S)/CP, \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,/L$$

$$\frac{\Box Nm, (Nm\backslash S)/CP, \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}{\Box Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,\Box L$$

Figure 10: De dicto derivation for *John believes that a fish walks*

$$
\begin{prooftree}
\AxiomC{}
\UnaryInfC{$CNn \Rightarrow CNn$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box CNn \Rightarrow CNn$}
\AxiomC{}
\UnaryInfC{$CNm \Rightarrow CNm$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box CNm \Rightarrow CNm$}
\AxiomC{}
\UnaryInfC{$Nn \Rightarrow Nn$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box Nn \Rightarrow Nn$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$\Box Nn, Nn\backslash S \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box Nn, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$\Box R$}
\UnaryInfC{$\Box Nn, \Box(Nn\backslash S) \Rightarrow \Box S$}
\AxiomC{}
\UnaryInfC{$CP \Rightarrow CP$}
\RightLabel{$/L$}
\BinaryInfC{$CP/\Box S, \Box Nn, \Box(Nn\backslash S) \Rightarrow CP$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \Rightarrow CP$}
\AxiomC{}
\UnaryInfC{$Nm \Rightarrow Nm$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$Nm, Nm\backslash S \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$Nm, (Nm\backslash S)/CP, \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$\uparrow R$}
\UnaryInfC{$1, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \Rightarrow S{\uparrow}Nm$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\downarrow L$}
\BinaryInfC{$(S{\uparrow}Nm){\downarrow}S, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$((S{\uparrow}Nm){\downarrow}S)/CNm, \Box CNm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(((S{\uparrow}Nm){\downarrow}S)/CNm), \Box CNm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$\uparrow R$}
\UnaryInfC{$\Box(((S{\uparrow}Nm){\downarrow}S)/CNm), \Box CNm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), 1, \Box(Nn\backslash S) \Rightarrow S{\uparrow}\Box Nn$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\downarrow L$}
\BinaryInfC{$\Box(((S{\uparrow}Nm){\downarrow}S)/CNm), \Box CNm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), (S{\uparrow}\Box Nn){\downarrow}S, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$\Box(((S{\uparrow}Nm){\downarrow}S)/CNm), \Box CNm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), ((S{\uparrow}\Box Nn){\downarrow}S)/CNn, \Box CNn, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(((S{\uparrow}Nm){\downarrow}S)/CNm), \Box CNm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \Rightarrow S$}
\end{prooftree}
$$

Figure 11: Existential widest scope derivation for *Every man believes that a fish walks*

$$\dfrac{}{Nn \;\Rightarrow\; Nn}$$

$$\dfrac{Nn \;\Rightarrow\; Nn}{\Box Nn \;\Rightarrow\; Nn}\,\Box L \qquad \dfrac{}{S \;\Rightarrow\; S}$$

$$\dfrac{\Box Nn \;\Rightarrow\; Nn \qquad S \;\Rightarrow\; S}{\Box Nn, Nn\backslash S \;\Rightarrow\; S}\,\backslash L$$

$$\dfrac{\Box Nn, Nn\backslash S \;\Rightarrow\; S}{\Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,\Box L$$

$$\dfrac{\Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; S}{\Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; \Box S}\,\Box R \qquad \dfrac{}{CP \;\Rightarrow\; CP}$$

$$\dfrac{\Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; \Box S \qquad CP \;\Rightarrow\; CP}{CP/\Box S, \Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; CP}\,/L$$

$$\dfrac{CP/\Box S, \Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; CP}{\Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; CP}\,\Box L \qquad \dfrac{\dfrac{}{Nm \;\Rightarrow\; Nm} \qquad \dfrac{}{S \;\Rightarrow\; S}}{Nm, Nm\backslash S \;\Rightarrow\; S}\,\backslash L$$

$$\dfrac{\Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; CP \qquad Nm, Nm\backslash S \;\Rightarrow\; S}{Nm, (Nm\backslash S)/CP, \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,/L$$

$$\dfrac{Nm, (Nm\backslash S)/CP, \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; S}{Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,\Box L$$

$$\dfrac{Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box Nn, \Box(Nn\backslash S) \;\Rightarrow\; S}{Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), 1, \Box(Nn\backslash S) \;\Rightarrow\; S{\uparrow}\Box Nn}\,{\uparrow}R \qquad \dfrac{}{S \;\Rightarrow\; S}$$

$$\dfrac{Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), 1, \Box(Nn\backslash S) \;\Rightarrow\; S{\uparrow}\Box Nn \qquad S \;\Rightarrow\; S}{Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), (S{\uparrow}\Box Nn){\downarrow}S, \Box(Nn\backslash S) \;\Rightarrow\; S}\,{\downarrow}L$$

$$\dfrac{\dfrac{}{CNn \;\Rightarrow\; CNn}}{\Box CNn \;\Rightarrow\; CNn}\,\Box L$$

$$\dfrac{\Box CNn \;\Rightarrow\; CNn \qquad Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), (S{\uparrow}\Box Nn){\downarrow}S, \Box(Nn\backslash S) \;\Rightarrow\; S}{Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), ((S{\uparrow}\Box Nn){\downarrow}S)/CNn, \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,/L$$

$$\dfrac{Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), ((S{\uparrow}\Box Nn){\downarrow}S)/CNn, \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}{Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,\Box L$$

$$\dfrac{Nm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}{1, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S{\uparrow}Nm}\,{\uparrow}R \qquad \dfrac{}{S \;\Rightarrow\; S}$$

$$\dfrac{1, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S{\uparrow}Nm \qquad S \;\Rightarrow\; S}{(S{\uparrow}Nm){\downarrow}S, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,{\downarrow}L$$

$$\dfrac{\dfrac{}{CNm \;\Rightarrow\; CNm}}{\Box CNm \;\Rightarrow\; CNm}\,\Box L$$

$$\dfrac{\Box CNm \;\Rightarrow\; CNm \qquad (S{\uparrow}Nm){\downarrow}S, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}{((S{\uparrow}Nm){\downarrow}S)/CNm, \Box CNm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,/L$$

$$\dfrac{((S{\uparrow}Nm){\downarrow}S)/CNm, \Box CNm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}{\Box(((S{\uparrow}Nm){\downarrow}S)/CNm), \Box CNm, \Box((Nm\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn, \Box(Nn\backslash S) \;\Rightarrow\; S}\,\Box L$$

Figure 12: Existential intermediate scope derivation for *Every man believes that a fish walks*

$$
\begin{prooftree}
\AxiomC{}
\UnaryInfC{$CN_m \Rightarrow CN_m$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box CN_m \Rightarrow CN_m$}
\AxiomC{}
\UnaryInfC{$CN_n \Rightarrow CN_n$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box CN_n \Rightarrow CN_n$}
\AxiomC{}
\UnaryInfC{$N_n \Rightarrow N_n$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box N_n \Rightarrow N_n$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$\Box N_n, N_n\backslash S \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box N_n, \Box(N_n\backslash S) \Rightarrow S$}
\RightLabel{$\uparrow R$}
\UnaryInfC{$1, \Box(N_n\backslash S) \Rightarrow S{\uparrow}\Box N_n$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\downarrow L$}
\BinaryInfC{$(S{\uparrow}\Box N_n){\downarrow}S, \Box(N_n\backslash S) \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$((S{\uparrow}\Box N_n){\downarrow}S)/CN_n, \Box CN_n, \Box(N_n\backslash S) \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(((S{\uparrow}\Box N_n){\downarrow}S)/CN_n), \Box CN_n, \Box(N_n\backslash S) \Rightarrow S$}
\RightLabel{$\Box R$}
\UnaryInfC{$\Box(((S{\uparrow}\Box N_n){\downarrow}S)/CN_n), \Box CN_n, \Box(N_n\backslash S) \Rightarrow \Box S$}
\AxiomC{}
\UnaryInfC{$CP \Rightarrow CP$}
\RightLabel{$/L$}
\BinaryInfC{$CP/\Box S, \Box(((S{\uparrow}\Box N_n){\downarrow}S)/CN_n), \Box CN_n, \Box(N_n\backslash S) \Rightarrow CP$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(CP/\Box S), \Box(((S{\uparrow}\Box N_n){\downarrow}S)/CN_n), \Box CN_n, \Box(N_n\backslash S) \Rightarrow CP$}
\AxiomC{}
\UnaryInfC{$N_m \Rightarrow N_m$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$N_m, N_m\backslash S \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$N_m, (N_m\backslash S)/CP, \Box(CP/\Box S), \Box(((S{\uparrow}\Box N_n){\downarrow}S)/CN_n), \Box CN_n, \Box(N_n\backslash S) \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$N_m, \Box((N_m\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box N_n){\downarrow}S)/CN_n), \Box CN_n, \Box(N_n\backslash S) \Rightarrow S$}
\RightLabel{$\uparrow R$}
\UnaryInfC{$1, \Box((N_m\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box N_n){\downarrow}S)/CN_n), \Box CN_n, \Box(N_n\backslash S) \Rightarrow S{\uparrow}N_m$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\downarrow L$}
\BinaryInfC{$(S{\uparrow}N_m){\downarrow}S, \Box((N_m\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box N_n){\downarrow}S)/CN_n), \Box CN_n, \Box(N_n\backslash S) \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$((S{\uparrow}N_m){\downarrow}S)/CN_m, \Box CN_m, \Box((N_m\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box N_n){\downarrow}S)/CN_n), \Box CN_n, \Box(N_n\backslash S) \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(((S{\uparrow}N_m){\downarrow}S)/CN_m), \Box CN_m, \Box((N_m\backslash S)/CP), \Box(CP/\Box S), \Box(((S{\uparrow}\Box N_n){\downarrow}S)/CN_n), \Box CN_n, \Box(N_n\backslash S) \Rightarrow S$}
\end{prooftree}
$$

Figure 13: Existential narrowest scope derivation for *Every man believes that a fish walks*

(33) $\forall C[(\check{\ } man\ C) \rightarrow ((\check{\ } believe\ \hat{\ }\exists H[(\check{\ } fish\ H) \wedge (\check{\ } walk\ H)])\ C)]$

The next example involves the *such that* relativization of Montague's fragment:

(34) (7-57) **every+fish+such+that+it+walks+talks** : S

This is relativization in which the clause subordinate to *such that* must contain a free anaphor. Semantically, the semantics of the body of the relative clause abstracted over the free pronoun meaning restricts the head modified by the relative clause. Since our grammar uses the Jäger anaphora type constructor, *such that* can be categorized accordingly. Lexical lookup produces the following semantically labelled sequent:

(35) $\Box(((S{\uparrow}NA){\downarrow}S)/CNA) : \hat{\ }\lambda B\lambda C\forall D[(B\ D) \rightarrow (C\ D)], \Box CNn : fish,$
$\Box((CNE\backslash CNE)/(S|NE)) : \hat{\ }\lambda F\lambda G\lambda H[(G\ H) \wedge (F\ H)],$
$\Box(\Box(S{\uparrow}Nn){\downarrow}(\Box S|Nn)) : \hat{\ }\lambda I\lambda J\hat{\ }(\check{\ }I\ J), \Box(NK\backslash S) : walk, \Box(NL\backslash S) : talk\ \Rightarrow\ S$

Note that the type for *it* used allows the pronoun to occupy either subject (nominative) or object (accusative) position and then pick up an antecedent outside its clause. We call such anaphora, in which a pronoun has an antecedent outside of its clause, *external* anaphora and use for it the limited contraction type-constructor. We contrast this with *internal* anaphora, in which a pronoun has a preceding antecedent in or within its own clause, and for which we use discontinuity connectives. The sequent has the derivation given in Figure 14. This delivers semantics:

(36) $\forall C[[(\check{\ } fish\ C) \wedge (\check{\ } walk\ C)] \rightarrow (\check{\ } talk\ C)]$

To allow a pronoun to take an antecedent within its own clause a second internal anaphora lexical type is given. But this is conditioned in accordance with Principle B of Chomsky (1981) to prevent a local subject antecedent (cf. Morrill and Valentín 2010a; 2013). Lexical lookup for the present example inserting this type yields the following sequent, which has no derivation.

(37) $\Box(((S{\uparrow}NA){\downarrow}S)/CNA) : \hat{\ }\lambda B\lambda C\forall D[(B\ D) \rightarrow (C\ D)], \Box CNn : fish,$
$\Box((CNE\backslash CNE)/(S|NE)) : \hat{\ }\lambda F\lambda G\lambda H[(G\ H) \wedge (F\ H)],$
$\Box(((((S{\uparrow}Nn){-}(J{\bullet}(Nn\backslash S))){\uparrow}\Box Nn){-}(J{\bullet}((Nn\backslash S){\uparrow}Nn))){\downarrow_{\_}}(S{\uparrow}\Box Nn)) : \hat{\ }\lambda I\lambda J((I\ J)\ \check{\ }J), \Box(NK\backslash S) :$
$walk, \Box(NL\backslash S) : talk\ \Rightarrow\ S$

The next example of DWP involves *seek* which is an intensional object verb synonymous with *try to find*:

(38) (7-60, 7-62) **john+seeks+a+unicorn** : S

The sentence has a specific reading in which there is a unicorn which John is trying to find, and a non-specific reading in which John is just trying to bring it about that he finds some, any, unicorn. The latter reading does not have existential commitment: it can be true without any unicorn existing in the actual world. Lexical lookup gives the following semantically labelled sequent:

(39) $\Box Nm : \hat{\ }j, \Box((NA\backslash S)/\Box(((NB\backslash S)/NC)\backslash(NB\backslash S))) :$
$\hat{\ }\lambda D\lambda E((tries\ \hat{\ }((\check{\ }D\ find)\ E))\ E), \Box(((S{\uparrow}\Box NF){\downarrow}S)/CNF) :$
$\hat{\ }\lambda G\lambda H\exists I[(G\ I) \wedge (H\ \hat{\ }I)], \Box CNn : unicorn\ \Rightarrow\ S$

For the specific reading there is the derivation given in Figure 15. This delivers the semantics with existential commitment:

(40) $\exists C[(\check{\ } unicorn\ C) \wedge ((tries\ \hat{\ }((find\ C)\ j))\ j)]$

For the nonspecific reading there is the derivation given in Figure 16. This delivers the semantics without existential commitment:

(41) $((tries\ \hat{\ }\exists G[(\check{\ } unicorn\ G) \wedge ((find\ G)\ j)])\ j)$

$$
\begin{prooftree}
\AxiomC{}
\UnaryInfC{$Nn \Rightarrow Nn$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$Nn, Nn\backslash S \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$Nn, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$\uparrow R$}
\UnaryInfC{$1, \Box(Nn\backslash S) \Rightarrow S{\uparrow}Nn$}
\RightLabel{$\Box R$}
\UnaryInfC{$1, \Box(Nn\backslash S) \Rightarrow \Box(S{\uparrow}Nn)$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box S \Rightarrow S$}
\RightLabel{$|R$}
\UnaryInfC{$\Box S|Nn \Rightarrow S|Nn$}
\RightLabel{$\downarrow L$}
\BinaryInfC{$\Box(S{\uparrow}Nn){\downarrow}(\Box S|Nn), \Box(Nn\backslash S) \Rightarrow S|Nn$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(\Box(S{\uparrow}Nn){\downarrow}(\Box S|Nn)), \Box(Nn\backslash S) \Rightarrow S|Nn$}
\AxiomC{}
\UnaryInfC{$CNn \Rightarrow CNn$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box CNn \Rightarrow CNn$}
\AxiomC{}
\UnaryInfC{$CNn \Rightarrow CNn$}
\RightLabel{$\backslash L$}
\BinaryInfC{$\Box CNn, CNn\backslash CNn \Rightarrow CNn$}
\RightLabel{$/L$}
\BinaryInfC{$\Box CNn, (CNn\backslash CNn)/(S|Nn), \Box(\Box(S{\uparrow}Nn){\downarrow}(\Box S|Nn)), \Box(Nn\backslash S) \Rightarrow CNn$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box CNn, \Box((CNn\backslash CNn)/(S|Nn)), \Box(\Box(S{\uparrow}Nn){\downarrow}(\Box S|Nn)), \Box(Nn\backslash S) \Rightarrow CNn$}
\AxiomC{}
\UnaryInfC{$Nn \Rightarrow Nn$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$Nn, Nn\backslash S \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$Nn, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$\uparrow R$}
\UnaryInfC{$1, \Box(Nn\backslash S) \Rightarrow S{\uparrow}Nn$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\downarrow L$}
\BinaryInfC{$(S{\uparrow}Nn){\downarrow}S, \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$((S{\uparrow}Nn){\downarrow}S)/CNn, \Box CNn, \Box((CNn\backslash CNn)/(S|Nn)), \Box(\Box(S{\uparrow}Nn){\downarrow}(\Box S|Nn)), \Box(Nn\backslash S), \Box(Nn\backslash S) \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box(((S{\uparrow}Nn){\downarrow}S)/CNn), \Box CNn, \Box((CNn\backslash CNn)/(S|Nn)), \Box(\Box(S{\uparrow}Nn){\downarrow}(\Box S|Nn)), \Box(Nn\backslash S), \Box(Nn\backslash S) \Rightarrow S$}
\end{prooftree}
$$

Figure 14: Derivation for *Every fish such that it walks talks*

$$
\begin{prooftree}
\AxiomC{}
\UnaryInfC{$Nn \Rightarrow Nn$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box Nn \Rightarrow Nn$}
\AxiomC{}
\UnaryInfC{$NA \Rightarrow NA$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$NA, NA\backslash S \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$NA, (NA\backslash S)/Nn, \Box Nn \Rightarrow S$}
\RightLabel{$\backslash R$}
\UnaryInfC{$(NA\backslash S)/Nn, \Box Nn \Rightarrow NA\backslash S$}
\RightLabel{$\backslash R$}
\UnaryInfC{$\Box Nn \Rightarrow ((NA\backslash S)/Nn)\backslash(NA\backslash S)$}
\RightLabel{$\Box R$}
\UnaryInfC{$\Box Nn \Rightarrow \Box(((NA\backslash S)/Nn)\backslash(NA\backslash S))$}
\AxiomC{}
\UnaryInfC{$Nm \Rightarrow Nm$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box Nm \Rightarrow Nm$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\backslash L$}
\BinaryInfC{$\Box Nm, Nm\backslash S \Rightarrow S$}
\RightLabel{$/L$}
\BinaryInfC{$\Box Nm, (Nm\backslash S)/\Box(((NA\backslash S)/Nn)\backslash(NA\backslash S)), \Box Nn \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box Nm, \Box((Nm\backslash S)/\Box(((NA\backslash S)/Nn)\backslash(NA\backslash S))), \Box Nn \Rightarrow S$}
\RightLabel{$\uparrow R$}
\UnaryInfC{$\Box Nm, \Box((Nm\backslash S)/\Box(((NA\backslash S)/Nn)\backslash(NA\backslash S))), 1 \Rightarrow S\uparrow\Box Nn$}
\AxiomC{}
\UnaryInfC{$S \Rightarrow S$}
\RightLabel{$\downarrow L$}
\BinaryInfC{$\Box Nm, \Box((Nm\backslash S)/\Box(((NA\backslash S)/Nn)\backslash(NA\backslash S))), (S\uparrow\Box Nn)\downarrow S \Rightarrow S$}
\AxiomC{}
\UnaryInfC{$CNn \Rightarrow CNn$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box CNn \Rightarrow CNn$}
\RightLabel{$/L$}
\BinaryInfC{$\Box Nm, \Box((Nm\backslash S)/\Box(((NA\backslash S)/Nn)\backslash(NA\backslash S))), ((S\uparrow\Box Nn)\downarrow S)/CNn, \Box CNn \Rightarrow S$}
\RightLabel{$\Box L$}
\UnaryInfC{$\Box Nm, \Box((Nm\backslash S)/\Box(((NA\backslash S)/Nn)\backslash(NA\backslash S))), \Box(((S\uparrow\Box Nn)\downarrow S)/CNn), \Box CNn \Rightarrow S$}
\end{prooftree}
$$

Figure 15: Specific reading derivation for *John seeks a unicorn*

$$
\frac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{}{CNn \Rightarrow CNn}}{\Box CNn \Rightarrow CNn}\,\Box L \qquad \dfrac{\dfrac{\dfrac{\dfrac{\dfrac{}{Nn \Rightarrow Nn}}{\Box Nn \Rightarrow Nn}\,\Box L \quad \dfrac{\dfrac{}{NA \Rightarrow NA} \quad \dfrac{}{S \Rightarrow S}}{NA, NA\backslash S \Rightarrow S}\,\backslash L}{NA, (NA\backslash S)/Nn, \Box Nn \Rightarrow S}\,/L}{NA, (NA\backslash S)/Nn, 1 \Rightarrow S{\uparrow}\Box Nn}\,{\uparrow}R \quad \dfrac{}{S \Rightarrow S}}{NA, (NA\backslash S)/Nn, (S{\uparrow}\Box Nn){\downarrow}S \Rightarrow S}\,{\downarrow}L}{NA, (NA\backslash S)/Nn, ((S{\uparrow}\Box Nn){\downarrow}S)/CNn, \Box CNn \Rightarrow S}\,/L}{NA, (NA\backslash S)/Nn, \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn \Rightarrow S}\,\Box L}{(NA\backslash S)/Nn, \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn \Rightarrow NA\backslash S}\,\backslash R}{\Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn \Rightarrow ((NA\backslash S)/Nn)\backslash(NA\backslash S)}\,\backslash R}{\Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn \Rightarrow \Box(((NA\backslash S)/Nn)\backslash(NA\backslash S))}\,\Box R \qquad \dfrac{\dfrac{\dfrac{}{Nm \Rightarrow Nm}}{\Box Nm \Rightarrow Nm}\,\Box L \quad \dfrac{}{S \Rightarrow S}}{\Box Nm, Nm\backslash S \Rightarrow S}\,\backslash L}{\dfrac{\Box Nm, (Nm\backslash S)/\Box(((NA\backslash S)/Nn)\backslash(NA\backslash S)), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn \Rightarrow S}{\Box Nm, \Box((Nm\backslash S)/\Box(((NA\backslash S)/Nn)\backslash(NA\backslash S))), \Box(((S{\uparrow}\Box Nn){\downarrow}S)/CNn), \Box CNn \Rightarrow S}\,\Box L}\,/L
$$

Figure 16: Nonspecific reading derivation for *John seeks a unicorn*

5 Conclusion

Dowty, Wall and Peters (1981) is an authoritative textbook and as such awards authority to its contents. And Montague Grammar is a monument. But Montague did not assign importance to syntax and he did not formalize it. Logical categorial grammar provides Montague Grammar with a logical syntax which is, furthermore, computational. This preserves Montague's stance on the rôle of analyses — to ascribe truth conditions — and reinforces his position on ambiguity such as quantificational ambiguity (cf. the title of Montague 1973): that by compositionality, all non-lexical ambiguity is syntactic.

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