

# A Proof-Theoretic Semantics for Transitive Verbs with an Implicit Object

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## Abstract

The paper presents a proof-theoretic semantics for sentences headed by transitive verbs allowing an unexpressed (implicit) object. Such sentences are shown to have the same (proof-theoretic) meaning as the same sentences with an explicit existentially quantified object **something**.

This semantics is contrasted with a model-theoretic semantics based on truth-conditions in models. The models used contain in their domain “filler” elements, that have an unclear extra-theoretic significance with an unclear ontological commitments. In contrast, the proof-theoretic meaning is appealing to formal (syntactic) resources that carry no ontological commitment.

Furthermore, the sameness of meaning is based on sameness of deductive role within a meaning-conferring proof-system, based on use.

## 1 Introduction

The purpose of this paper is to provide yet another argument for the benefits of *proof-theoretic semantics (PTS)*, when applied to natural language (NL), over the traditional *model-theoretic semantics (MTS)*, by focusing on what came be known as *unexpressed objects* of transitive verbs (also referred to as *implicit arguments*) as manifested, for example, by an intransitive use of a transitive verb, as in<sup>1</sup> (1(i)) and (1(ii)) below.

(i) John ate an apple      (ii) John ate      (1)

<sup>1</sup>All natural language expressions used in examples are displayed in the San Serif font, and are always mentioned, never used.

PTS is a theory of meaning serving as an alternative to the more traditional Model-Theoretic Semantics (MTS). While the latter identifies meaning with truth-conditions (in arbitrary models of a suitable form), the former identifies meaning with *canonical derivability conditions* in a meaning-conferring proof system. Those canonical derivability conditions provide *grounds for assertion*. For a presentation of the motivation for PTS and a discussion of its advantages over MTS, the reader is referred to the Introduction sections of Francez and Dyckhoff (2010) or Francez and Ben-Avi (2015), which present a PTS for extensive fragments of English. A full presentation can be found in Francez (2015b).

Turning to the unexpressed arguments, the essence of the MTS-based meaning is to interpret such arguments as *existentially quantified*. Hence, (1(ii)) above is seen as equivalent to

John ate something      (2)

with meaning expressed as usual by a (simply-typed)  $\lambda$ -term, here expressible in 1st-order logic (using simple types on variables and constants):

$\exists x^e . \text{eat}^{(e,(e,t))}(x, \mathbf{john})$       (3)

In Dowty (1982), (1(ii)) is seen as resulting from (1(i)) by a general procedure of *argument reduction*.

The structure of the rest of the paper is as follows. In Section 2 I briefly survey two recent approaches to obtaining the above mentioned truth-conditions (MTS-meaning). In Section 3 I briefly review the PTS of a minimal fragment of English in which the issue of unexpressed arguments arises. Fuller details about the PTS (for larger fragments) can be found in Francez and Dyckhoff (2010) or Francez and Ben-Avi (2015) and in part II of Francez (2015b). Section 4 presents the the

PTS account of the unexpressed argument issue, and compares it to the reviewed MTS accounts. Section 5 ends with some conclusions.

## 2 A brief review of some model-theoretic approaches

The topic of unexpressed argument has a long history. I will mainly relate to Blom et al. (2012) (see there for references to previous work), and to Giorgolo and Asudeh (2012).

The common feature of those treatments of the unexpressed argument is imposing the sameness of meaning of an intransitive verb used with an implicit argument with the meaning of that verb used transitively with an existentially quantified object. For example,

$$\llbracket \text{Mary ate} \rrbracket = \exists x. \llbracket \text{Mary ate } x \rrbracket \quad (4)$$

The difference between Blom et al. (2012) and Giorgolo and Asudeh (2012) is the formalism used for composing meanings, a difference immaterial for my purpose. I consider here only the issue of meaning of such constructs, and not with the syntax-semantics interface used to derive those meanings compositionally, so I will take Blom et al. (2012) as the representative of the MTS to implicit arguments.. A completely different model-theoretic approach is presented in Carlson (1984), appealing to models with (Neo Davidsonian) events and event modifiers. See Blom et al. (2012) for a discussion of this kind of MTS.

The main features of the proposed analysis are the following (expressed in a somewhat different notation).

1. The standard domains  $D_\tau$  of interpretation of types  $\tau$  in (simply-typed)  $\lambda$ -calculi are extended with extra elements, designated generically as  $*_\tau$ , called the *filler value* of the domain of  $\tau$ . The type-system is extended so that for every type  $\tau$  there is a corresponding extended type  $\tau^\circ$  accommodating the default value so that  $D_{\tau^\circ} = D_\tau \cup \{*_\tau\}$  (where the union is disjoint).

See below the qualms about this solution.

2. The lexical meaning of verbs licensing unexpressed objects is expressed via a function of

the (notationally slightly modified) form

$$\begin{aligned} & \mathbf{option}(x_{\tau_1}^\circ, F_{(\tau_1, \tau_2)}, d_{\tau_2}) \\ & =_{df.} \begin{cases} d & x = *_\tau \\ F(x) & \text{otherwise} \end{cases} \quad (5) \end{aligned}$$

Here  $d_{\tau_2}$  is the *default value* of type  $\tau_2$ , chosen according to a global strategy: an existential closure of the word in the lexical semantic value of which this particular use of **option** is embedded. The **option** operator is of type  $\tau_1^\circ \times (\tau_1, \tau_2) \times \tau_2$ . The function  $\lambda x. \mathbf{option}(x, F, d)$  is therefore of type  $(\tau_1^\circ, \tau_2)$ .

**Example 2.1** Consider the lexical semantic value associated<sup>2</sup> with the verb **ate**, assuming it licensed an implicit object.

$$\lambda y_{e^\circ} \lambda x_e. \mathbf{option}(\lambda u_e. \text{ate}_{(e, (e, t))}(u_e)(y_e), \exists x_e. \text{ate}(x)(y)) \quad (6)$$

Now consider the two cases for **ate**.

**explicit object:** Mary ate an apple

See Figure 1:

**implicit object:** Mary ate

See Figure 2:

The extra-theoretic interpretation of such ‘‘filler elements’’  $*_\tau \in D_{\tau^\circ}$  is non-obvious, as is the presence of such elements in lexical meaning assignments of NL words. They carry an ontological commitment which is left unexplained.

As an example of one problematic issue involving filler elements, consider *selectional restrictions*. Typically, they are ignored, but there are ways of incorporating them into the type-based analysis above. Suppose one wants to admit

Mary ate an apple

but to exclude

Mary ate a chair

Both are admissible by the above analysis. One way of imposing selectional restrictions is by refining the type  $e$ , to include a sub-type  $e_{\text{edible}}$ ,

<sup>2</sup>I ignore here the finer points involved in implementing this construction in *abstract categorial grammar*, orthogonal to my main concern.

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$$\begin{aligned}
& \lambda y_{e^o} \lambda x_e. \mathbf{option}(y_{e^o}, \lambda u_e. \mathit{ate}_{(e,(e,t))}(u_e)(y_e), \exists x_e. \mathit{ate}_{(e,(e,t))}(x)(y))(\llbracket \mathit{an apple} \rrbracket)(\llbracket \mathit{Mary} \rrbracket) \\
& = \lambda x_e. \mathbf{option}(\llbracket \mathit{an apple} \rrbracket, \lambda u_e. \mathit{ate}_{(e,(e,t))}(u_e)(y_e)(\llbracket \mathit{an apple} \rrbracket)(\llbracket \mathit{Mary} \rrbracket), \exists x_e. \mathit{ate}_{(e,(e,t))}(x)(y)) \\
& = \lambda u_e. \mathit{ate}(u_e)(\llbracket \mathit{an apple} \rrbracket)(\llbracket \mathit{Mary} \rrbracket) \\
& = \mathit{ate}(\llbracket \mathit{an apple} \rrbracket)(\llbracket \mathit{Mary} \rrbracket)
\end{aligned} \tag{7}$$

The second step is due to  $\llbracket \mathit{an apple} \rrbracket \neq *e$ .

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Figure 1:  $\llbracket \mathit{Mary ate an apple} \rrbracket$

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$$\begin{aligned}
& \lambda y_{e^o} \lambda x_e. \mathbf{option}(y_{e^o}, \lambda u_e. \mathit{ate}_{(e,(e,t))}(u_e)(y_e), \exists x_e. \mathit{ate}_{(e,(e,t))}(x)(y))(*_e)(\llbracket \mathit{Mary} \rrbracket) \\
& = \lambda x_e. \mathbf{option}(*_e, \lambda u_e. \mathit{ate}_{(e,(e,t))}(u_e)(*_e)(\llbracket \mathit{Mary} \rrbracket), \exists x_e. \mathit{ate}(x)(y))(\llbracket \mathit{Mary} \rrbracket) \\
& = \exists x_e. \mathit{ate}(x)(y)(\llbracket \mathit{Mary} \rrbracket) \\
& = \exists x_e. \mathit{ate}(x)(\llbracket \mathit{Mary} \rrbracket)
\end{aligned} \tag{8}$$

The second step is due to  $*_e = *_e$ .

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Figure 2:  $\llbracket \mathit{Mary ate} \rrbracket$

and requiring the object of  $\mathit{ate}$  to be of that sub-type (see Ben-Avi and Francez (2004)).

Is  $*_e$  of type  $e_{\mathit{addible}}$ ? One way out is to include separate filler values for each sub-type of  $e$ , e.g.,  $*_{e_{\mathit{addible}}}$ . But this cause a proliferation of those intelligible values as more selectional restrictions are imposed, for example, admitting

every girl smiled

but excluding

every chair smiled

by introducing a sub-type  $e_{\mathit{animate}}$  of  $e$  and requiring the subject of  $\mathit{smile}$  to be of this sub-type..

Populating models with unintelligible entities is typical to MTS in general. One of the main advantages of PTS is avoiding models an unintelligible entities with unclear ontological commitments, dealing only with syntactic entities, artefacts of meaning-conferring proof-systems.

### 3 A Proof-Theoretic Semantics for a fragment of English

#### 3.1 The language fragment

I briefly present in this section the core of a fragment  $E_0^+$  of English. The core fragment consists of sentences with intransitive and transitive verbs, and determiner phrases with a (count, singular)

noun and a determiner. For simplicity, I consider here only the positive determiners **every** and **some**. The inclusion of negative determiners such as **no** or **at most three** involve a certain complication (see Francez and Ben-Avi (2015)) that is orthogonal to the current issue. In addition, there is the copula **is**. For technical reasons (made clear in Francez and Dyckhoff (2010)) I avoid the use of proper names, and use quantified subjects instead. Some typical sentences are listed below.

every/some girl smiles (9)

every/some girl loves every/some boy (10)

A typical sentence with an unexpressed argument to be considered is

every girl ate (11)

I refer to expressions such as **every girl**, **some boy** as *determiner phrases* ( $dps$ ).

#### 3.2 The meaning-conferring proof-system

The  $PTS$  is based on a meaning-conferring natural-deduction-proof system  $N_0^+$  with introduction rules and elimination rules ( $I/E$ -rules) (see Figure 3). The proof-system is formulated over the language  $L_0^+$ , slightly extending  $E_0^+$ . Meta-variables

$X$  schematise nouns,  $P$  – intransitive verbs and  $R$  – transitive verbs. Meta-variable  $S$  ranges over sentences, and boldface lower-case  $\mathbf{j}, \mathbf{k}$ , etc., range over  $\mathcal{P}$ , a denumerable set of (*individual*) *parameters*, artefacts of the proof-system (not used to make assertions). Syntactically, a parameter in  $L_0^+$  is also regarded as a *dp*. If a parameter occurs in  $S$  in some position, I refer to  $S$  as a *pseudo-sentence*, and if *all* *dps* in  $S$  are parameters, the pseudo-sentence  $S$  is *ground*. The ground pseudo-sentences play the role of atomic sentences, and their meaning is assumed *given*, externally to the ND proof-system.

The original full system takes into account also *relative clauses*, due to presence of which some scope-related indexing is essential, as there may be more than just two scope levels. For the purpose of dealing with unexpressed arguments, it is enough to have simple sentences, with just two scope-levels, for the subject and object *dps*. Furthermore, the general sentential variable  $S$  can be instantiated by  $P(-)$ ,  $R(-, -)$  and  $R^u(-)$  for simple sentences headed by intransitive, transitive verbs and transitive verbs allowing intransitive use (lexically specified), respectively. Accordingly, I consider here a simplification of the original proof-system, not dealing with quantifier scope ambiguity. For any *dp*-expression  $D$  having a quantifier, I use the notation  $S[(D)]$  to refer to a sentence  $S$  having a designated position filled by  $D$ .

For example,  $S[(\text{every } X)]$  refers to a sentence  $S$  with a designated occurrence of every  $X$ . I use the conventions that within a rule, both  $S[D_1], S[D_2]$  refer to the *same* designated position in  $S$ . I use  $\Gamma, S$  for the context extending  $\Gamma$  with sentence  $S$ .

*Derivations* (tree shaped), ranged over by  $\mathcal{D}$  (possibly indexed) are defined recursively as usual. When presenting example derivations, the context  $\Gamma$  is left implicit, and the notation  $[\dots]_i$  indicates an assumption *discharged* by an application of a rule.

The following is a convenient *derived*  $E$ -rule, that can be used to shorten derivations.

$$\frac{\Gamma : S[(\text{every } X)] \quad \Gamma : \mathbf{j} \text{ isa } X}{\Gamma : S[\mathbf{j}]} (e\hat{E}) \quad (12)$$

For example,

$$\frac{\Gamma : \text{every girl smiled} \quad \Gamma : \mathbf{j} \text{ isa girl}}{\Gamma : \mathbf{j} \text{ smiled}} (e\hat{E})$$

### 3.3 Canonical derivations and meaning

Consider an arbitrary natural-deduction proof-system intended as being meaning-conferring for the operators in some object language.

**Definition 3.1** An  $\mathcal{N}$ -derivation  $\mathcal{D}$  for  $\vdash_{\mathcal{N}} \Gamma : \psi$  (for a compound  $\psi$ ) is canonical iff it satisfies one of the following two conditions.

- The last rule applied in  $\mathcal{D}$  is an  $I$ -rule (for the main operator of  $\psi$ ).
- The last rule applied in  $\mathcal{D}$  is an assumption-discharging  $E$ -rule<sup>3</sup> the major premise of which is some  $\varphi$  in  $\Gamma$ , and its encompassed sub-derivations  $\mathcal{D}_1, \dots, \mathcal{D}_n$  (of the minor premises) are all canonical derivations of  $\psi$ .
- Denote by  $\llbracket S \rrbracket_{\Gamma}^c$  the (possibly empty) collection of canonical derivations of  $S$  from  $\Gamma$ .

For  $\Gamma$  empty, the definition reduces to that of a traditional canonical proof. Note the recursion involved in this definition. The important observation regarding this recursion is that it always terminates via the first clause, namely by an application of an  $I$ -rule. I refer to such an application of an  $I$ -rule (ending a recursive path in the definition) as an *essential* application, the outcome of which is *propagated* throughout the canonical derivation by applications of the assumption-discharging  $E$ -rules. Note that each sub-derivation  $\mathcal{D}_i$  may start with an essential application of an  $I$ -rule, thus having “parallel” essential applications of that rule. I refer to a sequence of occurrences of  $\psi$  in a canonical  $\mathcal{D}$  starting in the conclusion of an essential application of an  $I$ -rule and ending in the conclusion of  $\mathcal{D}$  as a *propagation chain* of  $\psi$  in  $\mathcal{D}$ .

The major observation here is that the conclusion  $\psi$  of a canonical derivation  $\mathcal{D}$  from open assumptions, ending a propagation chain, was:

1. inferred (possibly more than once) by the *essential applications* of the  $I$ -rule of its main operator, and
2. *propagated* through applications of assumption-discharging  $E$ -rules<sup>4</sup> to its position as the final conclusion of  $\mathcal{D}$ .

<sup>3</sup>General elimination rules (GE) have this structure, hence their association with permuting conversions during normalisation. See more on this in Negri and von Plato (2001).

<sup>4</sup>In propositional intuitionistic logic, say with Gentzen’s  $NJ$  ND-system, this happens with disjunction.

$$\begin{array}{c}
\overline{\Gamma, S : S} \quad (Ax) \\
\\
\frac{\Gamma, \mathbf{j} \text{ isa } X : S[\mathbf{j}]}{\Gamma : S[(\text{every } X)]} \quad (eI) \quad \frac{\Gamma : \mathbf{j} \text{ isa } X \quad \Gamma : S[\mathbf{j}]}{\Gamma \vdash S[(\text{some } X)]} \quad (sI) \\
\frac{\Gamma : S[(\text{every } X)] \quad \Gamma : \mathbf{j} \text{ isa } X \quad \Gamma, S[\mathbf{j}] : S'}{\Gamma : S'} \quad (eE) \quad \frac{\Gamma : S[(\text{some } X)] \quad \Gamma, \mathbf{j} \text{ isa } X, S[\mathbf{j}] : S'}{\Gamma : S'} \quad (sE)
\end{array}$$

where  $\mathbf{j}$  is *fresh* in  $(eI)$ , and  $(sE)$ .

Figure 3: The simplified rules for  $N_0^+$

The (*reified*) meaning of a sentence  $S$  (in the considered object language), denoted by  $\llbracket S \rrbracket$ , is defined by

**Definition 3.2 (reified meaning)**

$$\llbracket S \rrbracket =^{df.} \lambda \Gamma. \llbracket S \rrbracket_{\Gamma}^c \quad (13)$$

This is a very fine-granularity notion of meaning, see Francez (2014). A natural coarsening is obtained by considering *grounds of assertion*.

**Definition 3.3 (grounds for assertion)**

$$GA\llbracket S \rrbracket = \{\Gamma \mid \vdash^c \Gamma : S\} \quad (14)$$

Thus, any  $\Gamma$  that canonically derives  $S$  serves as grounds for assertion of  $S$ . This is naturally extended to  $GA\llbracket \Gamma \rrbracket$ , the grounds of asserting all  $S' \in \Gamma$ . For the methodological role of this concept in the theory of meaning adhered to by PTS, see Dummett (1993).

By appealing to equality of grounds, we get an equivalence relation coarser than meaning as defined above, inducing a natural ‘sameness of meaning’ relation.

**Definition 3.4 (equi-groundedness)**  $S_1$  and  $S_2$  are equi-grounded, denoted by  $S_1 \equiv_{GA} S_2$ , iff  $GA\llbracket S_1 \rrbracket = GA\llbracket S_2 \rrbracket$ .

Grounds of assertion lead (see Francez (2015a)) to the following notion of *proof-theoretic consequence*, that captures the pre-theoretic entailment.

**Definition 3.5 (proof-theoretic consequences)**

$S$  is a proof-theoretic consequence of  $\Gamma$  ( $\Gamma \Vdash S$ ) iff  $GA\llbracket \Gamma \rrbracket \subseteq GA\llbracket S \rrbracket$ .

Thus, proof-theoretic consequences is based on *grounds propagation*: every grounds for collectively asserting all of  $\Gamma$  are already grounds for asserting  $S$ .

## 4 Proof-theoretic semantics for unexpressed arguments

In this section, I extend the proof-system with  $I/E$ -rules for the sentences allowing (lexically licensed) intransitive uses of transitive verbs, underlying the proof-theoretic account of their meaning.

The main ideas on which the PTS for implicit arguments is based is the following:

- *Sameness of meaning is based on sameness of I-rules, implying sameness of canonical derivations.*
- *The reduction of an argument is reflected proof-theoretically by omission of a premise (in I-rules).*

### 4.1 Adding something

As the alert reader might have noticed, all the *nps* in  $E_0^+$  contain an explicit noun-component; for example, *some girl, every boy*. I will refer to such *nps* as *nominally qualified*. Indeed, typical NL-quantification is what is known as *restricted quantification*. However, for the sake of the specification of the meaning of sentences with an implicit argument, what is needed<sup>5</sup> is to augment the language fragment with an *np* expressing *unrestricted existential quantification* in the form of *something*, lacking a nominal qualification.

The nominally-unqualified existential quantification in object position is governed by the fol-

<sup>5</sup>Another alternative is to consider a *universal noun* thing, and use it as the noun-qualifier. I consider this less elegant in the context of PTS.

lowing  $I/E$ -rules<sup>6</sup>.

$$\frac{\Gamma : \mathbf{j} R \mathbf{k}}{\Gamma : \mathbf{j} R \text{ something}} (usI)$$

$$\frac{\Gamma : \mathbf{j} R \text{ something} \quad \Gamma, \mathbf{j} R \mathbf{k} : S'}{\Gamma : S'} (usE) \quad \mathbf{k} \text{ fresh.} \quad (15)$$

The difference between those two  $I/E$ -rules and the  $I/E$ -rules for nominally-qualified  $nps$  ( $(sI)$  and  $(sE)$  below) is the absence of a nominally-qualifying premise  $\mathbf{k} \text{ isa } X$  (for some noun  $X$ ) in the  $I$ -rule, and the absence of a corresponding discharged assumption in the  $E$ -rule.

For example,

$$\frac{\Gamma : \mathbf{j} \text{ ate } \mathbf{k}}{\Gamma : \mathbf{j} \text{ ate something}} (usI)$$

$$\frac{\Gamma : \mathbf{j} \text{ ate something} \quad \Gamma, \mathbf{j} \text{ ate } \mathbf{k} : S'}{\Gamma : S'} (usE) \quad \mathbf{k} \text{ fresh}$$

## 4.2 Sentential meanings

In contrast to the view of argument reduction (mentioned above), I present *separate*  $I$ -rules for the transitive and intransitive uses of sentences with  $R^u$ -verbs; furthermore, the *same*  $I$ -rule serves *both* for the introduction for sentences with  $R^u$ -verbs with an unexpressed object *and* for the corresponding  $R$  with an explicit object *something*. This establishes the *sameness of meaning* of pairs of sentences like (1(ii)) and (2), where this sameness of meaning is based on both sentences having the same grounds of assertion.

### Transitive verb with an expressed object:

These are the usual rules  $(sI)$  and  $(sE)$ , simplified to objects only, of simple sentences.

$$\frac{\Gamma : \mathbf{k} \text{ isa } X \quad \Gamma : \mathbf{j} R \mathbf{k}}{\Gamma : \mathbf{j} R \text{ some } X} (sI)$$

$$\frac{\Gamma : \mathbf{j} R \text{ some } X \quad \Gamma, \mathbf{k} \text{ isa } X, \mathbf{j} R \mathbf{k} : S'}{\Gamma : S'} (sE) \quad \mathbf{k} \text{ fresh} \quad (16)$$

<sup>6</sup>Similar rules govern something in a subject position, but they do not matter here and are omitted.

### Transitive verb with an unexpressed object:

$$\frac{\Gamma : \mathbf{j} R^u \mathbf{k}}{\Gamma : \mathbf{j} R^u} (uI)$$

$$\frac{\Gamma : \mathbf{j} R^u \quad \Gamma, \mathbf{j} R^u \mathbf{k} : S'}{\Gamma : S'} (uE) \quad \mathbf{k} \text{ fresh} \quad (17)$$

Here only a sentence with an  $R^u$ -verb can be used. Note the “missing” premise  $\mathbf{k} \text{ isa } X$  (for some  $X$ ), leaving the object nominally-unqualified, hence omit-able. It is crucial to note that the subject of  $R^u$  *has to be a parameter*, assuring the meaning-identity with the explicit existentially case below. The parameter  $\mathbf{j}$  is a basis for introduction of a universally quantified subject with a higher scoping quantifier.

For example, with  $R^u = \text{ate}$  (with contexts omitted):

$$\frac{\mathbf{j} \text{ ate } \mathbf{k}}{\mathbf{j} \text{ ate}} (uI) \quad \frac{\mathbf{j} \text{ ate} \quad \mathbf{j} \text{ ate } \mathbf{k} : S'}{\Gamma : S'} (uE) \quad \mathbf{k} \text{ fresh} \quad (18)$$

Note that no similar  $(uI)$ -application can be used to derive, for example,  $\mathbf{j} \text{ smiled}$ , under the assumption that  $\text{smiled}$  is a proper intransitive verb.

### Example 4.2 As an example, I show that

$$\vdash \text{every girl ate some apple} : \text{every girl ate} \quad (19)$$

The derivation is shown in Figure 4. So, the “essence” of the derivation is not using the premise  $\mathbf{k} \text{ isa apple}$ , later discharged by the application of  $(sE)$ , in deriving  $\mathbf{j} \text{ ate}$ .

## 4.3 Sameness of meaning

The following proposition, expressing the equality of meaning between intransitive  $R^u$ -headed pseudo-sentence and explicitly existentially-quantified  $R$ -headed pseudo-sentences is a simple consequence of those rules.

### Proposition 4.1

$$\llbracket \mathbf{j} R^u \rrbracket = \llbracket \mathbf{j} R \text{ something} \rrbracket \quad (21)$$

and in particular

$$\mathbf{j} R^u \equiv_{GA} \mathbf{j} R \text{ something} \quad (22)$$

**Proof:** immediate, as there is a one-one correspondence between canonical derivations on both

$$\frac{\frac{[j \text{ isa girl}]_1 \quad \text{every girl ate some apple}}{j \text{ ate some apple}} \quad (e\hat{E}) \quad \frac{[j \text{ ate } k]_2, [k \text{ isa apple}]_3}{j \text{ ate}} \quad (uI)}{\frac{j \text{ ate}}{\text{every girl ate}} \quad (eI^1)} \quad (sE^{2,3}) \quad (20)$$

Figure 4: Derivation of every girl ate

sides of the equality, because the premises of the respective  $I$ -rules are the same.

A consequence of proposition 4.1 is the following theorem<sup>7</sup>, establishing that the sameness of meaning for ground pseudo-sentences with  $R^u$ -verbs extends to a congruence of sameness of meaning for arbitrary sentences with  $R^u$ -verbs in the fragment (namely, arbitrary quantified  $nps$  as subject). As we have here only two possible subjects, we state the theorem for both, explicitly.

**Theorem 4.1**

$$\llbracket \text{every } X R^u \rrbracket = \llbracket \text{every } X R \text{ something} \rrbracket \quad (23)$$

$$\llbracket \text{some } X R^u \rrbracket = \llbracket \text{some } X R \text{ something} \rrbracket \quad (24)$$

**Proof:** Suppose  $\mathcal{D}$  is a canonical derivation of every  $X R^u$ . Then, omitting contexts,  $\mathcal{D}$  has to have a subderivation of the following form.

$$\frac{[j \text{ isa } X]_i \quad \frac{\mathcal{D}'}{j R^u}}{\text{every } X R^u} \quad (eI^i) \quad (25)$$

There are two sub-cases to consider, depending whether  $\mathcal{D}'$  itself is canonical or not.

1. First, assume  $\mathcal{D}'$  is canonical. By proposition 4.1,  $\mathcal{D}'$  is also a canonical derivation of

$$\frac{[j \text{ isa } X]_i \quad \mathcal{D}'}{j R \text{ something}}$$

And, hence,

$$\frac{[j \text{ isa } X]_i \quad \frac{\mathcal{D}'}{j R \text{ something}}}{\text{every } X R \text{ something}} \quad (eI^i) \quad (26)$$

<sup>7</sup>Note that neither Blom et al. (2012) nor Giorgolo and Asudeh (2012) relate to this issue, discussing only sentences with proper names as subjects.

is a canonical derivation, establishing

$$\llbracket \text{every } X R^u \rrbracket \subseteq \llbracket \text{every } X R \text{ something} \rrbracket \quad (27)$$

Showing

$$\llbracket \text{every } X R \text{ something} \rrbracket \subseteq \llbracket \text{every } X R^u \rrbracket \quad (28)$$

is similar.

2. Next, suppose  $\mathcal{D}'$  is not canonical. Thus, the conclusion  $j R^u$  was obtained by an application of an  $E$ -rule. In the small fragment considered here, there are two possible  $E$ -rules that could yield this consequence.

- (a) The one possibility is the  $(e\hat{E})$ -rule. This means that  $\mathcal{D}'$  must have the following form.

$$\frac{\frac{\mathcal{D}'_1 \quad \mathcal{D}'_2}{\text{every } Y R^u} \quad j \text{ isa } Y}{j R^u} \quad (e\hat{E}^j)$$

In the subderivation  $\mathcal{D}'_1$ , the conclusion must have been introduced by the  $(eI)$ -rule. So this premise looks like

$$\frac{[k \text{ isa } Y]_j \quad \frac{\mathcal{D}''_1}{k R^u}}{\text{every } Y R^u} \quad (eI^j)$$

Since  $\mathcal{D}''_1$  is smaller than  $\mathcal{D}$ , by induction it follows that

$$\frac{[k \text{ isa } Y]_j \quad \frac{\mathcal{D}''_1}{k R \text{ something}}}{\text{every } Y R \text{ something}} \quad (eI^j)$$

from which we get the required derivation

$$\frac{\frac{\mathcal{D}'_1}{\text{every } Y R \text{ something}} \quad \mathcal{D}'_2}{j R \text{ something}} \quad (e\hat{E}^j)$$

The other direction is similar.

- (b) The other possibility is that the relevant  $E$ -rules are ( $sE$ ) and ( $uE$ ) (for a subject some  $X$ ). The details are similar to the previous case and omitted.

This proof could be extended for subjects with other determiners, e.g. *at least seven girls ate*, having the same meaning as *at least seven girls ate something*, not in the current fragment, though.

There is an interesting observation arising from the proof-theoretic meaning device above. Consider sentences with *intensional* transitive verb (ITVs) with an indefinite object  $np$ , like

Mary seeks/looks for a secretary (29)

Such sentences are known to have a *notional* reading (unspecific) of their object. Thus, (29) has a reading by which Mary looks for *any* secretary.

Such sentences have no equivalent counterpart with an unexpressed object.

(\*) Mary seeks/looks for (30)

The explanation for the impossibility of the object omission can be found in the proof-theoretic semantics for ITVs provided in Francez (2016). Under this semantics, the objects of ITVs are *different kind of parameters* than the individual parameters, for which the omission rules present here do not apply. This shows the power of syntactic methods, introducing formal distinctions not carrying any ontological commitments, unlike the need to populate models with entities of unclear nature as in model-theoretic semantics.

## 5 Conclusions

In this paper I have presented a proof-theoretic semantics for sentences headed by transitive verbs allowing an unexpressed (implicit) object. Such sentences are shown to have the same (proof-theoretic) meaning as the same sentences with an explicit existentially quantified object *something*.

This semantics is contrasted with a model-theoretic semantics based on truth-conditions in models. The models used contain in their domain “filler” elements, that have an unclear extra-theoretic significance with an unclear ontological commitments. In contrast, the proof-theoretic meaning is appealing to formal (syntactic) resources that carry no ontological commitment.

Furthermore, the sameness of meaning is based on sameness of deductive role within a meaning-conferring proof-system, based on use.

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