Thematic Uniqueness:
Model-Theoretic or Proof-Theoretic?

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May 22, 2018

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1   Introduction

- Despite the field's long-standing interest in raising (1), a phenomenon whose study has flourished since Rosenbaum (1967), copy raising (2) has not received as much attention in theoretical linguistics.

  (1)   Thora seemed to enjoy the game.

  (2)   Thora seemed like she enjoyed the game.

- The 'copy' pronoun in (2) is obligatory (for most speakers; Asudeh 2012: chapter 12), which raises the question of the status of the copy raising subject's role as an argument in the semantics.

- This is further complicated by the fact that copy raising, like subject-to-subject raising, alternates with an expletive-subject variant:

  (3)   It seemed like Thora enjoyed the game.

- In Asudeh and Toivonen (2012), we motivate a semantic role that we call PSOURCE for the copy-raised subject. We argue against using the existing thematic role STIMULUS, essentially based on the expletive alternation in (2)/(3), as well as broader theoretical considerations.

- Our treatment of PSOURCE was inspired by a paper by **Greg Carlson** (Carlson 1984), a pioneering work on event semantics

- In today's talk, I want to return to Greg's paper and a problem that it discusses, Thematic Uniqueness, in light of some puzzling facts about Swedish copy raising.

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2 Overview

3 Background: Copy Raising

- Copy raising is a phenomenon in which a raising verb takes a non-expletive subject and a complement containing an obligatory pronominal 'copy' of the subject, as shown again here for English:

  (4)   a.   Thora seems like she's found the chocolate.
          b.   *Thora seems like Alfred's found the chocolate.

- Swedish displays a similar alternation:

  (5)   a.   Thora verkar som om hon har hittat chokladen.
                 Thora seems as   if   she has found chocolate.the
                 'Thora seems like she has found the chocolate.'
          b.   * Thora verkar som om Alfred har hittat chokladen.
                  Thora seems as   if   Alfred has found chocolate.the

- Swedish also has the capacity to express the PSOURCE in a *på*-PP, but in that case it cannot also be expressed as a subject:

  (6)   a.   Det verkar på Thora som om hon har hittat chokladen.
                 It   seems on Thora as   if   she has found chocolate.the
                 'Thora seems like she has found the chocolate.'
          b.   * Thora verkar på Isak/Thora som om hon har hittat chokladen.
                  Thora seems on Isak/Thora as   if   she has found chocolate.the

- English copy raising was first discussed extensively in work by Rogers (1971, 1972, 1973, 1974), although it did receive a brief mention on the first major extended work on raising Postal (1974: 268, fn.1). To our knowledge, Asudeh and Toivonen (2012) is the first work to discuss Swedish copy raising in any detail. For further references, see Asudeh and Toivonen (2012, 2017).

4   Background: Thematic Uniqueness

- Carlson (1984: 270–273) discusses the status of thematic roles in the grammar and issues raised by the apparent universal constraint against verbs like the made up verb *skick*, which takes a subject that is an AGENT and two objects that are both LOCATION (or PATIENT — the exact thematic role doesn't matter).

  (7)   John skicked Bill's leg Bill's shin.   (Carlson 1984: 271, (11))
           (Meaning: John kicked Bill on the shin part of his leg)

- Carlson (1984) concludes that there must be some principle of Thematic Uniqueness (TU), which states that any eventuality can have at most one instance of any particular thematic role.

- Carlson further argues that TU should not be captured either strictly semantically or syntactically, but is rather a constraint on eventualities (Carlson 1984: 273).

- One way of capturing Thematic Uniqueness is through a principle such as the following:.

  (8)   **Unique Role Requirement**   (Landman 2000: 38)
           If a thematic role is specified for an event, it is uniquely specified.

- The question is how to operationalize this. There is a long tradition in the literature that captures the Unique Role Requirement in the model theory by defining thematic roles as partial functions from eventualities to individuals (Chierchia 1984, 1989, Landman 2000, Champollion 2015, 2017).

- The underlying explanation for the ill-formedness of (9) and (10) is thus potentially the same:

  (9)   *John kicked Bill's leg Bill's shin.

  (10)   * Tom verkar på Robin som om han skrattar.
            Tom seems on Robin as   if   he   laughs

- Carlson assumes that (9) involves an attempt to assign two instances of a LOCATION thematic role and therefore violates the requirement that each event have at most one instance of a given role.

- Under the model-theoretic treatment of the uniqueness requirement, this follows from the definition of thematic roles as functions.

- Similarly, (10) involves two instances of the PSOURCE function and is blocked for the same reason.

5   The Problem: Model Theory is Too Weak

- There is, however, reason to believe that denotational or model-theoretic uniqueness is not a sufficiently strong uniqueness requirement.

- In particular, model-theoretic uniqueness makes false empirical predictions in cases of denotational equivalence, a fact that was already foreseen by Carlson (1984: 272).

- **To foreshadow:** The solution is to therefore introduce a proof-theoretic notion of uniqueness that guarantees uniqueness irrespective of denotation.

  ○ It is important to realize that the two notions do not conflict: Proof-theoretic uniqueness is independent of the model-theory and it can therefore supplement model-theoretic denotation rather than necessarily supplanting it.

  ○ Furthermore, proof-theoretic uniqueness does not introduce any new mechanisms into the theory, since it relies only on the mechanism that already regulates functor-argument composition and, specifically, proper predicate saturation and argument consumption.

- Consider example (10) if *Tom* and *Robin* are different names for the same individual.

  (10)   * Tom verkar på Robin som om han skrattar.
             Tom seems on Robin as   if   he   laughs

  ○ If the names are denotationally equivalent, then there is no violation of model-theoretic uniqueness, since the PSOURCE function is simply returning two different instances of the same individual.

  ○ This particular case is perhaps not too worrying, though, since it could potentially be handled through the use of intensions (depending on how the semantics of proper names is treated).

- A potentially more problematic case is where there are two occurrences of the same individual using the same name, which is equally ill-formed:

  (11)   * Tom verkar på Tom som om han skrattar.
             Tom seems on Tom as   if   he   laughs

  ○ Here we have very strong denotational equivalance between the two individuals designated by *Tom* and model-theoretic uniqueness breaks down.

- It may be, however, that independent factors account for the ill-formedness of (11).

  ○ First, there is a potential Principle C violation in terms of binding theory (Chomsky 1981), although given the weakness of Principle C (Evans 1980) this seems like a tenuous explanation for the strong ungrammaticality of (11).

  ○ One might instead contend that repeated uses of the same name use different guises (Castañeda 1972, 1989, Heim 1998). This might also explain the ungrammaticality of (10).

- However, none of these explanations can readily account for the ungrammaticality of a parallel example with a reflexive in the *på*-PP:

  (12)   * Tom verkar på sig själv som om han skrattar.
              Tom seems on himself as   if   he   laughs

  ○ The reflexive in this example is not logophoric or special in any way: It must be denotationally equivalent to its antecedent.

  ○ Yet the sentence is ill-formed despite the model-theoretic/denotational equivalence of the subject and the adjunct.

- We are therefore led to reconsider denotational uniqueness in the model as the means of capturing the Unique Role Requirement, which is repeated here:

  (13)   **Unique Role Requirement**   (Landman 2000: 38)
              If a thematic role is specified for an event, it is uniquely specified.

- The conclusion we have reached is that in generalizing this notion to PSOURCEs, the expression "uniquely specified" in (13) cannot be understood as "having a unique denotation in the model", which is what the usual functional understanding of thematic roles captures.

- The data in (10–12) indicates that — when extended to eventuality participants in general, including PSOURCEs — the uniqueness requirement is that eventuality participants are uniquely *overtly* realized, i.e. that they have at most one syntactic realization.

- Yet Carlson (1984: 270–272) cautions us against understanding thematic roles as purely syntactic constructs, as they seem to do no purely syntactic work. And, in any case, the Swedish *på*-PP does not seem to be a syntactic argument (Asudeh and Toivonen 2012).

- In sum, it is insufficient to capture the uniqueness requirement solely in terms of the model-theoretic semantics.

- Rather, it must somehow be stated as a condition on the mapping from the syntax to the semantics.

6 A Solution: Proof-Theoretic Uniqueness

- A method for correctly capturing the uniqueness requirement becomes apparent if we consider more basic cases of thematic roles with respect to uniqueness:[1]

  (14)   * Tom skrattar sig själv.
            Tom laughs   him self

  ○ The model-theoretic treatment of the uniqueness requirement on thematic roles does not block this sentence, since the subject and the reflexive are denotationally equivalent. They could both be assigned the thematic role AGENT, for example.

  ○ In theory-neutral terms, what actually blocks (14) is instead whatever ensures proper predicate saturation or, equivalently, argument consumption.

  ○ The sentence is bad because *skratta* ('laugh') takes only one argument and the second argument cannot be handled properly.

- It is instructive to consider this in light of the Theta Criterion (Chomsky 1981: 36):

  (15)   **Theta Criterion**
            Each argument bears one and only one θ-role and each θ-role is assigned to one and only one argument.

- Chierchia (1984) explicitly relates the uniqueness requirement on thematic roles to the Theta Criterion.

  ○ He argues that treating thematic roles as functions captures the second part of the Theta Criterion.

  ○ We have seen that this is in fact only true up to denotational equivalence.

  ○ However, it is if anything the first part of the Theta Criterion that blocks (14): The object does not bear a theta role, since the sole theta role of the verb is assigned to the subject.

  ○ But in subsequent work in the Minimalist Program, the first clause of the Theta Criterion was abandoned (Brody 1993, Bošković 1994, Hornstein 1999) and Chomsky (1995: 200) has argued that the entire principle can be subsumed under Full Interpretation (FI).

- If FI is to be construed as a restriction on semantic interpretation or the mapping from Logical Form to the Conceptual–Intentional System, it cannot explain the ungrammaticality of (12), repeated here, since it receives a perfectly valid (if redundant) compositional interpretation:

  (12)   * Tom verkar på sig själv som om han skrattar.
            Tom seems on himself as   if   he   laughs

  (16) $\exists s.seem(s, \exists e[laugh(e, tom) \land \text{AGENT}(e) = tom]) \land \text{PSOURCE}(s) = tom \land \text{PSOURCE}(s) = tom$

- I've previously argued that Full Interpretation can be reduced to a proof-theoretic notion of *resource sensitivity* (Asudeh 2004: 99ff., Asudeh 2012: Chapter 5).

- Resource sensitivity is captured through the use of a resource logic for semantic composition, as in Glue Semantics (Dalrymple 1999, 2001, Asudeh 2012), which uses the resource logic *linear logic* (Girard 1987) for composition.

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[1] I use a Swedish example to ensure that the reflexive is not understood emphatically, as it could be in the equivalent English sentence (on a par with *Tom himself laughs*). The emphatic reflexive in Swedish would just be *själv*, without *sig*.

- Premises in linear logic proofs are resources whose use is tightly controlled: A successful linear logic proof requires each premise to be used exactly once.

- Asudeh (2012) calls the resource sensitivity that stems purely from properties of the underlying logic *Logical Resource Sensitivity*.

  (17)   **Logical Resource Sensitivity**
          In a resource logic, premises in proofs cannot be freely *reused* or *discarded*.

- A related notion that is more useful for linguistics, *Linguistic Resource Sensitivity*, is derived by stating a linguistically motivated goal condition on the linear logic proof for semantic composition (Asudeh 2012: 106–110).

  (18)   **Linguistic Resource Sensitivity**
          Elements of combination in grammars cannot be freely *reused* or *discarded*.

  ○ In the absence of such a goal condition, the premises could be properly used up by simply conjoining them all together, but this does not derive a properly composed meaning.

  ○ A typical goal condition in Glue Semantics is the following:

    (19) $\Gamma \vdash \phi : s$

  ○ From a premise set Γ, the goal is to establish an atomic conclusion s that corresponds to the interpretation of the sentence, represented as ϕ.[2]

- On this view, (14), repeated here, is ill-formed because there are resources contributed by the subject and object, but the verb only consumes the subject resource, illicitly leaving behind the object resource.

  (14)   * Tom skrattar sig   själv.
            Tom laughs   him self

- This is schematized in the following proof ($\multimap$ is linear implication and $\otimes$ is the relevant kind of linear conjunction):

  (20) $$\frac{\dfrac{\text{SUBJECT} \qquad \text{SUBJECT} \multimap \text{VERB}}{\text{VERB} \qquad\qquad \text{OBJECT}}}{\text{VERB} \otimes \text{OBJECT}}$$

- Notice that argument consumption corresponds to implication elimination.

- The goal condition (19) is not met, since the result is a conjunction, not an atomic term.

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[2]The linear logic terms are also typed and the type of the conclusion here is t. I leave typing aside here, since it is not relevant to the point at hand.

- This suggests a way to address the problem of denotational uniqueness by replacing the model-theoretic version of the uniqueness requirement with a proof-theoretic version.

- The basic idea is to extend the calculus of argument consumption to PSOURCEs, but without necessarily treating them as arguments (which we argue against in Asudeh and Toivonen 2012).

- This is accomplished by embedding the meanings for raising verbs and the *på*-PP adjuncts in a Glue Semantics analysis that introduces a PSOURCE resource in the linear logic term for semantic composition.

- Linguistic Resource Sensitivity will then yield a proof-theoretic uniqueness requirement that works regardless of denotation.

- Note that this proof-theoretic treatment does not conflict with model-theoretic uniqueness and we will continue to assume that PSOURCEs and thematic roles are partial functions.

- Rather than attempting to demonstrate proof-theoretic uniqueness in the abstract, let us work through the relevant cases.

- First let us consider subject-to-subject raising and expletive examples in English and Swedish:

    (21) a. Tom seems to be laughing.

          b. Tom verkar skratta.
              Tom seems laugh.INF
              'Tom seems to be laughing.'

    (22) a. It seems like Tom is laughing.

          b. Det verkar som om Tom skrattar.
              It   seems as if T. laughs
              'It seems as if Tom is laughing.'

- The interpretations for these cases are presented here as two separate terms (whose proper interaction is captured in the Glue logic side, presented below):

    (23) $\lambda p \lambda s'.seem(s', p)$
          $\lambda S \lambda s.\exists v[S(s) \wedge \text{PSOURCE}(s) = v]$

    ○ Asudeh and Toivonen (2012) argue that the existential closure is obligatory in both English and Swedish subject-to-subject raising and in English expletive examples.

    ○ The closure is only optional in Swedish expletive examples, to allow composition with a *på*-PP adjunct.

- These interpretations are embedded in Glue meaning constructors, which pair terms of the meaning language with linear logic terms:

    (24) $\lambda p \lambda s'.seem(s', p)$:
          COMPLEMENT $\multimap$ PSOURCE $\multimap$ EVENT $\multimap$ RESULT

          $\lambda S \lambda s.\exists v[S(s) \wedge \text{PSOURCE}(s) = v]$:
          (PSOURCE $\multimap$ EVENT $\multimap$ RESULT) $\multimap$ (EVENT $\multimap$ RESULT)

- The linear logic terms are provided schematically here, but normally they would be instantiated in terms of some syntactic theory, such as LFG (Bresnan et al. 2016).

- Crucially, a linear logic term is introduced for the PSOURCE.

- This will serve as a resource that must be properly consumed in the linear logic proof.

- The other linear logic terms stand for the raising verb's sentential complement, the event variable, and the result of composition.

- It is important to bear in mind that linear logic terms with identical names in proofs are meant to be understood as token-identical.

- The composition of the examples in (21–22) proceeds as in (25), leaving aside details of the complement (for details, see Asudeh and Toivonen 2012). The linear logic are here abbreviated terms in order to save space.

(25)

$$
\cfrac{
  \cfrac{
    \cfrac{\lambda p\lambda s'.seem(s',p):}{C \multimap P \multimap E \multimap R} \qquad \cfrac{laugh(\dots):}{C}
  }{\lambda s'.seem(s', laugh(\dots)): \atop P \multimap E \multimap R} \qquad
  \cfrac{\lambda S\lambda s.\exists v[S(s) \wedge \textsc{Psource}(s) = v]:}{(P \multimap E \multimap R) \multimap (E \multimap R)}
}{
  \cfrac{\lambda S.\exists s[S(s)]: \atop (E \multimap R) \multimap R \qquad \lambda s.\exists v[seem(s, laugh(\dots)) \wedge \textsc{Psource}(s) = v]: \atop E \multimap R}{\exists s\exists v[seem(s, laugh(\dots)) \wedge \textsc{Psource}(s) = v]: R}
}
$$

- Notice that implication elimination in the linear logic corresponds to functional application in the meaning language (via the Curry-Howard isomorphism; Curry and Feys 1958, Howard 1980).

- I assume standard existential closure of the matrix event variable s in the absence of other quantification.

- The crucial step is the one where the existential closure $\exists v$ applies to the raising verb's meaning.

  ○ On the linear logic side, the existential closure needs to consume an implication from a PSOURCE, which is provided by the raising verb.

  ○ This is a standard higher-type functor-argument application for a quantifier combining with its scope.

  ○ The final result is an atomic linear logic term corresponding to the sentential semantics, which satisfies the goal condition (19) above.

- Let us next see the meaning constructor for the Swedish preposition *på* in a *på*-PP PSOURCE adjunct:

(26) $\lambda x\lambda S\lambda s.S(s) \wedge \textsc{Psource}(s) = x :$
      OBJECT $\multimap$
         (MODIFIEE'S PSOURCE $\multimap$ MODIFIEE'S EVENT $\multimap$ MODIFIEE'S RESULT) $\multimap$
            (MODIFIEE'S EVENT $\multimap$ MODIFIEE'S RESULT)

- The Glue logic side treats the adjunct as a modifier on a term that depends on a PSOURCE.

- In this respect, the *på*-adjunct is like the existential closure term in (24).

- Both contribute linear logic terms that want to consume a dependency on a PSOURCE. This is sufficient to explain the ungrammaticality of Swedish subject-to-subject raising with a *på*-PP:

(27)   * Tom verkar på Sara skratta.
         T.   seems on S.   laugh.INF

- The existential closure of PSOURCE is obligatory in this case.

- This means that both the existential closure meaning constructor and the *på*-PP meaning constructor are seeking to consume a term of the form PSOURCE $\multimap$ EVENT $\multimap$ RESULT.

- However, only one instance of this term has been contributed by the verb.

- The resource sensitivity of linear logic entails that once one of these PSOURCE consumers has consumed the dependency on the verb's PSOURCE, there is no way to satisfy the other consumer.

- This is shown schematically in the following packed proof:

(28)

$$
\frac{
  \begin{array}{c}
  \exists\text{-clos./på-PP} \\
  (P \multimap E \multimap R) \multimap (E \multimap R)
  \end{array}
  \quad
  \frac{
    \begin{array}{cc}
    \begin{array}{c}\textbf{raising verb}\\ C \multimap P \multimap E \multimap R\end{array} & \begin{array}{c}\textbf{complement}\\ C\end{array} \\
    \end{array}
    \qquad
    \frac{
      \begin{array}{c}\exists\text{-clos./på-PP}\\ (P \multimap E \multimap R) \multimap (E \multimap R)\end{array}
    }{}
  }{
    \begin{array}{cc} P \multimap E \multimap R & \qquad\qquad E \multimap R \end{array}
  }
}{
  [(P \multimap E \multimap R) \multimap (E \multimap R)] \otimes (E \multimap R)
}
$$

- It is readily apparent that the final result is not an atomic term and that (19) is therefore not satisfied.

- Lastly, let us consider copy raising:

(29) a. Tom seems like he is laughing.

       b. Tom verkar som om han skrattar.
          T.   seems as   if he laughs
          'Tom seems as if he is laughing.'

- In both English and Swedish, the copy-raised subject serves as the PSOURCE.

- This is captured by embedding the copy raising verb's meaning in the following meaning constructor:

(30) $\lambda x \lambda P \lambda s . seem(s, P(x)) \wedge \text{PSOURCE}(s) = x :$
      SUBJECT/PSOURCE $\multimap$ (SUBJECT $\multimap$ COMPLEMENT) $\multimap$ EVENT $\multimap$ RESULT

- Notice that for non-expletive variants (i.e., true copy raising), there is no existential closure, since we want the matrix copy raising subject to be the PSOURCE.

- In our syntactic analysis (Asudeh and Toivonen 2012, Asudeh 2012), the copy-raised subject is structure-shared with the implicit subject of the predicative *like/som* complement and the copy raising verb composes its subject with the property corresponding to its complement.

- From a resource-logical perspective, the important aspect of the linear logic term in (30) is that the only consumer of the matrix subject/PSOURCE is the copy raising verb.

- If a *på*-PP modifies a copy raising verb, there are two possible proofs, but neither terminates in an atomic linear logic term.

- The first possibility is if the copy raising verb composes with its subject directly.

- There is then no dependency on a PSOURCE left in the proof and the *på*-PP modifier cannot find its scope. This is shown schematically here:

(31)

$$
\begin{array}{c}
\dfrac{\textbf{subject} \quad\quad \textbf{CR verb}}{S \quad\quad\quad S/P \multimap (S \multimap C) \multimap E \multimap R} \\
\hline
(S \multimap C) \multimap E \multimap R
\end{array}
\qquad
\begin{array}{c}
\vdots \\
\textbf{complement} \\
\textbf{property} \\
S \multimap C
\end{array}
\qquad
\begin{array}{c}
\textbf{på-PP} \\
(P \multimap E \multimap R) \multimap (E \multimap R)
\end{array}
$$

$$
\dfrac{E \multimap R}{\quad}
$$

$$
(E \multimap R) \otimes (P \multimap E \multimap R) \multimap (E \multimap R)
$$

- Alternatively, if the på-PP adjunct consumes the dependency on the PSOURCE, then there is no longer a consumer for the matrix subject, since the subject and the PSOURCE are one and the same.

- This is shown schematically in the following proof, where the term for the copy raising verb has been curried to compose with the complement first, for ease of presentation:

(32)

$$
\begin{array}{c}
\vdots \\
\textbf{complement} \\
\textbf{property} \\
\end{array}
$$

$$
\begin{array}{c}
\textbf{CR verb} \\
(S \multimap C) \multimap S/P \multimap E \multimap R \quad\quad S \multimap C
\end{array}
\qquad
\begin{array}{c}
\textbf{på-PP} \\
(P \multimap E \multimap R) \multimap (E \multimap R)
\end{array}
$$

$$
\dfrac{P \multimap E \multimap R}{\quad}
$$

$$
\begin{array}{c}
\textbf{subject} \\
S
\end{array}
\qquad\qquad
E \multimap R
$$

$$
S \otimes (E \multimap R)
$$

- **A *på*-PP therefore cannot co-occur with a copy raising verb for proof-theoretic reasons:** There are not enough instances of the subject/PSOURCE to satisfy all consumers (the copy raising verb and the adjunct).

- This proof-theoretic treatment of PSOURCE uniqueness is entirely independent of denotations and depends solely on the linear logic terms for semantic composition.

- Proof-theoretic uniqueness therefore blocks all instances of copy raising with *på*-PP adjuncts, including the denotationally equivalent instances in (10–12) above and particularly the pernicious reflexive case, repeated here:

(33)   * Tom verkar på sig själv som om han skrattar.
        T.   seems on him self as   if   he   laughs

This example is ill-formed for the proof-theoretic reasons just outlined with respect to the proofs (31) and (32) above.

- Since Glue proofs are essentially structural representations of the syntax-semantics interface (Asudeh and Crouch 2002a,b), proof-theoretic uniqueness therefore has the desired property of controlling for the linguistic realization of PSOURCEs through the mapping from syntax to semantics, based on the resources underlying contributions of PSOURCE, rather than controlling for denotational equivalence in the model-theoretic semantics.

7 Conclusion

- The basis for proof-theoretic uniqueness is Linguistic Resource Sensitivity, which controls proper argument consumption by predicates.

- I argued that it is this latter notion that could be responsible for blocking cases involving thematic roles that denotational uniqueness lets slips through, such as unlicensed reflexives.

- The proof-theoretic control on functor-argument combination effected by Linguistic Resource Sensitivity was generalized to PSOURCEs by assigning them a resource that must be properly consumed in the proof, although in the model-theoretic semantics they are still not treated as arguments.

- Proof-theoretic uniqueness is thus a stronger condition than model-theoretic uniqueness, although the independence of the two kinds of uniqueness means that there is no conflict between the two and they can be captured simultaneously in one system, as they have been here, since we still assume that thematic/semantic roles are functions on eventualities, as per Carlson's original pioneering insight.

- One problem remains, however. Normally, we assume a strong correspondence between proofs and models, as captured by the Curry-Howard Isomorphism (Curry and Feys 1958, Howard 1980).

  ○ The solution sketched here puts some stress on that correspondence if it is construed as a correspondence between the terms in the meaning language and the terms in the Glue logic.

  ○ It is worth pointing out, though, that the correspondence is preserved between the compositional structure of the proof itself, as captured in rules of proof, and the models for the proofs.

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