Computational Perspectives on Linguistic Problems

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1 Introduction

Main goals of the talk

1. Introduce substructural logics

   (a) *Linear logic*: a resource logic

   (b) Linear logic for semantic composition (computational semantics)

2. Application to theoretical issues in linguistics

   (a) Proofs as a formalization and representation of the syntax–semantics interface (proof theory)

   (b) A logic of feature checking and interpretation

   (c) Hypothesis of Resource Sensitivity

   - Reduction of linguistic principles to resource-logical semantic composition
     i. Theta Criterion
     ii. No Vacuous Quantification
     iii. Full Interpretation
     iv. The Inclusiveness Condition

3. Application to empirical issues in linguistics

   - Resource Sensitivity as the basis of a new theory of resumption
   (a) Resumption as a problem of semantic composition
   (b) Generalized resumption: resumptive pronouns, copy raising

Principal empirical phenomena

1. *Resumptive pronouns* in unbounded dependencies

   (1) **Irish**

        a. Relative clause
            an ghirseach ar   ghoid na síogaí í
            the girl   COMP.PAST stole the fairies her
            the girl that the fairies stole away
            (McCloskey 2002: 189, (9b))

            Literally: 'the girl that the fairies stole her away'

        b. Wh-question
            Céacu ceann a   bhfuil dúil agat ann?
            which one   COMP is   liking at.you in.it
            Which one do you like?
            (McCloskey 2002: 189, (10b))

            Literally: 'Which one do you like it?'

   Among others: Arabic, Greek, Hebrew, Igbo, Persian, Scots Gaelic, Swedish, Welsh

2. Pronouns in copy raising (*copy pronouns*)

   (2) **English**
        No runner seems like she just ran a marathon.

   Among others: Dutch, Greek, Haitian Creole, Igbo, Irish, Persian, Swedish, Turkish

2   Substructural logics

- Restall (2000):

  > Substructural logics focus on the behaviour and presence — or more suggestively, the *absence* — of *structural rules*. These are particular rules in a logic which govern the behaviour of collections of information.

- Utility of substructural logics in computer science and interfacing fields:

  1. Precisely model behaviour of different types of information
  2. Fine-grained treatment of logical connectives
  3. Model processes and resources
  4. Logic programming techniques

- Three key structural rules and the intuitions behind them:

  Weakening: Premises can be *freely added*.

  Contraction: Additional occurrences of a premise can be *freely discarded*.

  Commutativity: Premises can be *freely reordered*.

- A proof-theoretic presentation:

  (3)
  | *Weakening* | *Contraction* | *Commutativity* |

  $$\frac{\Gamma \vdash B}{\Gamma, A \vdash B} \qquad \frac{\Gamma, A, A \vdash B}{\Gamma, A \vdash B} \qquad \frac{\Gamma, A, B \vdash C}{\Gamma, B, A \vdash C}$$

- **Resource logic**: a substructural logic that lacks weakening and contraction

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

  (5)   **Linguistic Resource Sensitivity**:
  Natural language is universally *resource-sensitive*.
  Elements of combination in grammars cannot be freely *reused* or *discarded*.

- Hierarchy of logics related by structural rules:
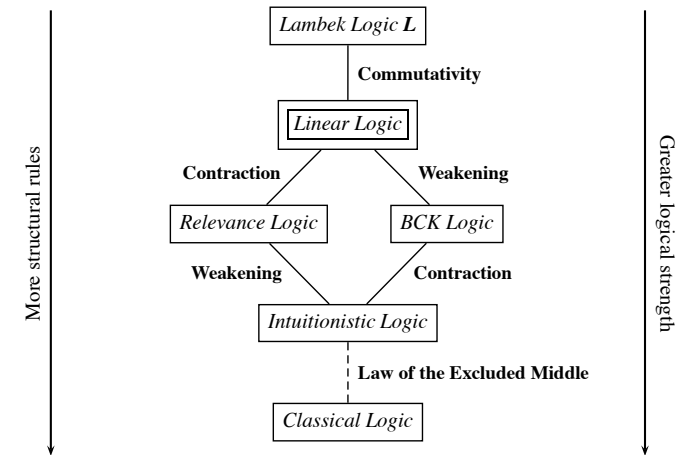
- **Linear logic** (Girard 1987): a commutative resource logic

- Linear logic (LL) premises must each be used *exactly* once: no reuse or deletion of premises (LL instantiates Logical Resource Sensitivity)

  (6)

Premise reuse	
Classical/Intuitionistic Logic	Linear Logic
$A,\ A \to B \vdash B$	$A,\ A \multimap B \vdash B$
$A,\ A \to B \vdash B \wedge A$	$A,\ A \multimap B \nvdash B \otimes A$
Premise A reused, conjoined with conclusion B	Premise A is consumed to produce conclusion B, no longer available for conjunction with B

  (7)

Premise nonuse	
Classical/Intuitionistic Logic	Linear Logic
$A, B \vdash A$	$A, B \nvdash A$
Can ignore premise B	Cannot ignore premise B

  Note: $\multimap$ is linear implication, $\otimes$ is multiplicative linear conjunction

2.1   Linear logic and proof theory

- **Proof theory**: the study of proofs as formal objects

  - Original impetus for linear logic

- Linear logic resources are premises, assumptions and conclusions in logical proofs (Crouch and van Genabith 2000)

- Proof rules for connectives, e.g. implication:

  (8)   Implication Elimination   Implication Introduction
            (modus ponens)   (hypothetical reasoning)

$$\frac{A \qquad A \multimap B}{B} \;\; {\multimap}_{\mathcal{E}} \qquad\qquad \frac{\begin{array}{c}[A]^1\\ \vdots\\ B\end{array}}{A \multimap B} \;\; {\multimap}_{\mathcal{I},1}$$

- Curry-Howard Isomorphism ("formulas-as-types"; Curry and Feys 1958, Howard 1980): correspondence between proof rules and proof terms

  (9)   Functional Application :   Abstraction :
            Implication Elimination   Implication Introduction

$$\frac{a : A \qquad f : A \multimap B}{f(a) : B} \;\; {\multimap}_{\mathcal{E}} \qquad\qquad \frac{\begin{array}{c}[x : A]^1\\ \vdots\\ f : B\end{array}}{\lambda x.f : A \multimap B} \;\; {\multimap}_{\mathcal{I},1}$$

2.2   Linear logic and computational semantics

- Glue Semantics (Dalrymple et al. 1993, Dalrymple 1999, 2001)

  - Natural language semantics using linear logic

  - Computational implementation: Constraint-Based Semantics Project at (Xerox) PARC (Principal implementation: Dick Crouch
    Development: Dick Crouch, Ash Asudeh, John Fry)

- Semantic composition:

  - *Meaning constructors* obtained from lexical items instantiated in syntactic parse

  - Each constructor has the form $\mathcal{M} : G$, where

    - $\mathcal{M}$ is a term from some meaning language
    - G is a term of linear logic

- Composition consists of linear logic proofs on meaning constructors

- Capitalizes on Curry-Howard Isomorphism

- Computational benefits:

  1. Well-understood formal/implementational properties
  2. Proof packing/structure sharing: ambiguity management
  3. Efficient algorithms (skeleton-modifier)

3   Theoretical applications

3.1   Proofs and the syntax–semantics interface

- Proof theory: proofs as first class objects

  - Requires strong identity criteria:
    - Avoid mistaking a *syntactic representation* of a proof for the abstract object it models
    - Need to know when two proofs are really distinct

  $\Longrightarrow$ Proof normalization (Prawitz 1965) and the Curry-Howard Isomorphism (Curry and Feys 1958, Howard 1980)

  (10)

$$\frac{a : \mathbf{A} \qquad \dfrac{[x : A]^1 \qquad f : \mathbf{A} \multimap \mathbf{B}}{\dfrac{f(x) : B}{\lambda x.f(x) : A \multimap B}\, {\multimap}_{\mathcal{I},1}}\, {\multimap}_{\mathcal{E}}}{(\lambda x.f(x))(a) : B} \;\; {\multimap}_{\mathcal{E}}$$

  Normalization / equivalence by β/η-reduction $\Longrightarrow$

  (11)

$$\frac{a : \mathbf{A} \qquad f : \mathbf{A} \multimap \mathbf{B}}{f(a) : B} \;\; {\multimap}_{\mathcal{E}}$$

- Linguistic applications:

  1. Proofs as a representation and formalization of the syntax–semantics interface with strong identity criteria (Asudeh and Crouch 2002a,b)

  2. Proofs and parallelism (Asudeh and Crouch 2002a,b):
     - Scope   (Hirschbühler 1982, Fox 2000)
     - Coordination   (Kehler 2002)

  3. Proof-theoretic uniqueness (Asudeh and Toivonen 2004)

  4. Direct compositionality and proof-theoretic semantic composition (Asudeh to appear)

3.2 A logic of feature checking and interpretation

- Asudeh and Potts (2004):

  – The distinction between interpretable and uninterpretable features in the Minimalist Program (Chomsky 1995) has no stable *semantic* basis.

    ○ This does *not* mean that the interpretable/uninterpretable distinction is arbitrary.

  – All features denote functions (interpreted): uninterpretable/interpretable distinction eliminated as a property of features

  – Feature checkers eliminate certain features (uninterpretable), do no eliminate others (interpretable): context-dependent view of interpretability

3.2.1 A logic for feature checking: $\mathcal{L}_{fc}$

(12)

Implication	**Conjunction**	**Identity**
(elimination)	(introduction)	(elimination)
$\dfrac{A \multimap B \quad A}{B} \multimap_{\mathcal{E}}$	$\dfrac{A \quad B}{A \otimes B} \otimes_{\mathcal{I}}$	$\dfrac{A \quad \mathbf{1}}{A} \mathbf{1}_{\mathcal{E}}$

- Properties of the logic $\mathcal{L}_{fc}$:

  1. Extremely weak
  2. Permits implication elimination
  3. Permits conjunction introduction
  4. Permits identity elimination
  5. Has no mechanism for introducing features

$\Rightarrow$ It is quite surprising that such a weak logic (= strong theory, in the linguist's sense) could form the basis for an aspect of linguistic competence.

- Features and feature checkers

  (13)   INST   [atomic feature/resource]

  (14)   INST $\multimap$ INST   [identity checker]

 (15)   INST $\multimap \mathbf{1}$ [eliminative checker]

- Contextual intepretation: Russian instrumental

  (16)   Instrumental unchecked (interpretable), roughly means *with*
  Otets redzet xleb nozh-om.
  father cuts bread knife-INST
  Father cuts bread with a knife.

  (17)   Instrumental checked (uninterpretable), selected for by *byt'*
  On budet professor-om.
  he will-be professor-INST
  He will be a professor.

3.3 Resource Sensitivity

- **Semantic composition**

  1. Order unimportant:
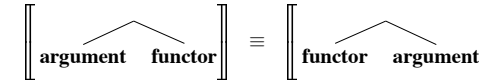
  2. Elements of semantic combination cannot be freely discarded or reused.

- Order irrelevant to functor-argument composition:

  – *Syntactic* constraints on the distribution of the syntactic realizations of functors and arguments, but not semantically relevant

  – Intransitive verb always follows its subject:

    ○ Verb=functor, Subject=argument → right-left functor-argument order
    ○ Type-raising:
      Subject=functor, Verb=argument → left-right functor-argument order

$\Rightarrow$ Semantic composition is commutative

- Cannot simply disregard contentful expressions or use single occurrences of contentful expressions more than once

  (18)   Kim fooled Sandy. $\Rightarrow$ $fool(kim, sandy)$
                                 $\not\Rightarrow$ $fool(kim, kim)$

  (19)   This innocent man is allegedly guilty, according to some.
       $\not\equiv$ This allegedly innocent man is allegedly guilty, according to some.

$\Rightarrow$ Semantic-composition is resource-sensitive

- Linear logic is an appropriate logic for semantic composition: **commutative resource-logic**

  (20)   **Linguistic Resource Sensitivity**:
  Natural language is universally *resource-sensitive*.
  Elements of combination in grammars cannot be freely *reused* or *discarded*.

- If the logic for semantic composition contains only implication, then Logical Resource Sensitivity of linear logic is sufficient to capture Linguistic Resource Sensitivity.

- The typical fragment used is the multiplicative fragment: contains conjunction.

$\Rightarrow$ Logical Resource Sensitivity insufficient, because it can be satisfied by simply conjoining all premises.

$\Rightarrow$ Need a linguistically motivated goal condition:

  (21) $\Gamma \vdash \phi : s_t$

  (22)   Thora laughed.   * Thora laughed Isak.

$$\frac{thora : A \quad laugh : A \multimap B}{laugh(thora) : B} \multimap_{\mathcal{E}}$$

$$\frac{\dfrac{thora : A \quad laugh : A \multimap B}{laugh(thora) : B} \multimap_{\mathcal{E}} \quad isak : C}{laugh(thora) \times isak : B \otimes C} \otimes_{\mathcal{I}}$$

[violates (21)]

3.4   Resource Sensitivity and linguistic theory

3.4.1   Theta Criterion

- Chomsky (1986):

    Each argument α appears in a chain containing a unique visible θ-position P, and each θ-position P is visible in a chain containing a unique argument α.

- **Issues/problems**:

    1. Multiple theta-roles to single argument (Jackendoff 1972, Chomsky 1981: 139):

    (23)   John deliberately rolled down the hill.

    (24)   Kim sang and danced.

    2. Redundancy with other principles (Chomsky 1993: 32)

- Carlson (1984): real purpose of Theta Criterion is to serve as a check on functor-argument matching

- Resource Sensitivity:

    – Ensures one-to-one functor-argument matching in the general case, properly handles coordination (Asudeh and Crouch 2002a)

    – Argument can carry multiple theta-roles while providing a single resource

3.4.2   No Vacuous Quantification

- Kratzer (1995: 131):

    (25)   *Prohibition against Vacuous Quantification*
                For every quantifier Q, there must be a variable x such that Q binds an occurrence of x in both its restrictive clause and its nuclear scope.

- Heim and Kratzer (1998: 126, (11)):

    (26)   Each variable binder must bind at least one variable.

- Chomsky (1982: 11, (6–7)):

    (27)   *all some men

    (28)   a. *the man who John saw Bill
                b. *Who did John see Bill?
                c. *I wonder who John saw Bill.

- Kratzer (1995: 129ff.):

    (29)   *When Mary knows French, she knows it well.

    (30)   When a Moroccan knows French, she knows it well.

- Fox (2000) builds his account of the Coordinate Structure Constraint on NVQ.

- **Issues/problems**:

    1. Marsh and Partee (1984), Potts (2002b): Complexity of NVQ quite bad and beyond what natural language is thought to maximally require (indexed grammar)

    2. Potts (2002b): Data motivating NVQ can be successfully analyzed using GPSG (Gazdar et al. 1985), but GPSGs are context-free (too weak).

        $\Rightarrow$ These phenomena cannot require NVQ.

- Resource Sensitivity: NVQ follows from the types of the expressions involved

    (31) $$\frac{\dfrac{(e \multimap t) \multimap ((e \multimap t) \multimap t) \qquad (e \multimap t)}{(e \multimap t) \multimap t} {\multimap_{\mathcal{E}}} \qquad (e \multimap t)}{t} {\multimap_{\mathcal{E}}}$$

    (32)   a. *All some men laughed.

                b. $$\frac{\dfrac{\dfrac{\overset{\textbf{some}}{(e \multimap t) \multimap ((e \multimap t) \multimap t)} \quad \overset{\textbf{men}}{(e \multimap t)}}{((e \multimap t) \multimap t)} {\multimap_{\mathcal{E}}} \quad \overset{\textbf{laugh}}{(e \multimap t)}}{t} {\multimap_{\mathcal{E}}} \quad \overset{\textbf{all}}{(e \multimap t) \multimap ((e \multimap t) \multimap t)}}{t \otimes ((e \multimap t) \multimap ((e \multimap t) \multimap t))}$$

        [violates (21)]

3.4.3 Full Interpretation

- Chomsky (1986: 98)

  We might express many of these ideas by saying that there is a principle of full interpretation (FI) that requires that every element of PF [Phonetic Form — AA] and LF [Logical Form — AA], taken to be the interface of syntax (in the broad sense) with systems of language use, must receive an appropriate interpretation — must be licensed in the sense indicated. None can simply be disregarded.

  (33)   a.   I was in England last year [the man]
           b.   John was here yesterday [walked]
           c.   [who] John saw Bill
           d.   [every] everyone was here

- **Issues/problems**:

  1. Vague and unformalized (but see Adger 2003): open to interpretation.
     How to implement?
  2. Status as separate principle suspicious: should be part of formal model/theory itself
  3. Potts (2002a): FI is a transderivational economy condition

- Resource Sensitivity:

  1. Strongly formalized in terms of resource logics, proof theory, type theory. Implemented.
  2. Integral part of the theory of semantic composition.
  3. Not transderivational: condition on single structure (a proof)

3.4.4 The Inclusiveness Condition

- A "perfect language" should meet the "condition of inclusiveness" (Chomsky 1995: 228):

  Any structure formed by the computation (in particular, π and λ) is constituted of elements already present in the lexical items selected for N; no new objects are added in the course of the computation apart from rearrangements of lexical properties ...

- Resource Sensitivity:

  1. Entails the inclusiveness condition:
     The multi-set of lexically obtained premises (the "numeration") must be exhaustively used up.
  2. Stronger condition than the inclusiveness condition:
     Not only can no items be entered into computation during derivation, the existing items cannot be reused and all existing items must be used up.

4 Empirical applications

- Resource Sensitivity forms the basis of a generalized theory of **resumption**: resumptive pronouns, copy raising

- Theory based on:

  – Syntax (lexical specification, local and unbounded dependencies, binding)
  – Semantic composition

4.1 Principal empirical phenomena

1. *Resumptive pronouns* in unbounded dependencies

   (34)   **Irish**

        a.   Relative clause
            an ghirseach ar   ghoid na síogaí í
            the girl   COMP.PAST stole   the fairies   her
            the girl that the fairies stole away
            (McCloskey 2002: 189, (9b))

            Literally: 'the girl that the fairies stole her away'

        b.   Wh-question
            Céacu ceann a   bhfuil dúil agat ann?
            which one   COMP is   liking at.you in.it
            Which one do you like?
            (McCloskey 2002: 189, (10b))

            Literally: 'Which one do you like it?'

   Among others: Arabic, Greek, Hebrew, Igbo, Persian, Scots Gaelic, Swedish, Welsh

2. Pronouns in copy raising (*copy pronouns*)

   (35)   **English**
          No runner seems like she just ran a marathon.

   Among others: Dutch, Greek, Haitian Creole, Igbo, Irish, Persian, Swedish, Turkish

4.2   What *is* a resumptive pronoun?

(36)   Every girl thinks that the fairies menaced <u>her</u>.

(37)   *Every girl who the fairies menaced <u>her</u> wept.

- (36): not a resumptive pronoun

- (37): a resumptive pronoun

   (**Note:** Resumptive pronouns in unbounded dependencies are not licensed in English[1])

- Why? What is the definition of a resumptive pronoun?

- **Despite the substantial literature on resumptive pronouns:**

   - **Quite difficult to define *resumptive pronoun* in a theoretically sound manner**

   - **The term is typically defined only ostensively.**

4.2.1   Case 1: Resumption in unbounded dependencies

Note: *Unbounded dependency* is a theory-neutral term for *wh-movement*.

- **Common intuition**:

   - The resumptive pronoun in (37) occurs where a gap/trace might occur.

   - The non-resumptive pronoun in (36) does not:

(38)   *Every girl thinks that the fairies menaced.

(39)   Every girl who the fairies menaced __ wept.

---

[1]English has resumptive-like pronouns as a sort of repair or complexity-amelioration strategy:

(i)   I'd like to meet the linguists who Kate can never remember if Thora has met them.

However, these are severely restricted in distribution in comparison to full-fledged unbounded dependency resumptives in other languages. Asudeh (2004) provides a psycholinguistically motivated processing model for production and processing of these resumptive-like pronouns.

- **Resumptive pronoun (definition 1)**
   A resumptive pronoun is a pronoun that occurs at the end of an unbounded dependency.

   - **Problems:**

      1. Resumptive pronouns by and large do not behave as if they are in typical unbounded dependencies, i.e. filler-gap dependencies.

         (a) Resumptives are generally not island-sensitive.
             (McCloskey 1979, 1990, 2002, Sells 1984).

         (b) Resumptives do not show weak crossover effects.
             (McCloskey 1990).

         (c) Resumptives trigger different morphological effects from gaps/traces.
             (McCloskey 1979, Sells 1984, Merchant 2001).

      2. Not sufficiently general

- **Resumptive pronoun (definition 2)**
   A resumptive pronoun is a pronoun that is operator bound.
   (Sells 1984: 16)

   - **Problem:**

      1. Fails to distinguish between the non-resumptive pronoun in (36) and the resumptive pronoun in (37) (repeated here):

         (36)   Every girl thinks that the fairies menaced <u>her</u>.

         (37)   *Every girl who the fairies menaced <u>her</u> wept.

         (At Logical Form (LF) the quantified subject of (36) is an operator, since it moves to a non-argument position by quantifier raising)

- **Resumptive pronoun (definition 3)**
   A resumptive pronoun is a pronoun that is operator bound at S-structure.
   (Sells 1984: 26, Sells 1987: 1)

   - **Problems:**

      1. Presumes a model of grammar that is derivational / transformational.
         The definition therefore fails to extend to monostratal / non-transformational syntactic theories.

      2. S-structure is not even an accepted level in the latest version of transformational grammar (the Minimalist Program; Chomsky 1995).

4.2.2 Case 2: Resumption in copy raising

- **Problem shared by unbounded dependency definition (def. 1) and operator-binding definition (def. 3)**:

  1. **Insufficiently general**:
     Fail to cover the intuitively resumptive-like use of pronouns in copy raising:

     (40)   Every baby seemed like <u>she</u> had eaten the crackers.

     (41)   *Every baby seemed like I had eaten the crackers.

  - Copy raising subject is licensed in the position occupied by the copy pronoun, not in matrix subject position

  - As in unbounded dependency resumption, the pronoun is "resuming" the reference of a displaced constituent

  - Connection made in other recent work: Ura (1998), Boeckx (2003)

- The **operator-binding definition** cannot distinguish between copy raising and S-structure binding of a resumptive, as in (37).

  - The copy pronoun's antecedent must be in an argument position at S-structure in order to satisfy the subject requirement of English clauses.
    (e.g., the Extended Projection Principle).

  - The pronoun is therefore not operator-bound at S-structure.

  ⇒ **In terms of operator-binding, copy raising is equivalent to the non-resumptive sentence (36) rather than the resumptive sentence (37).**

- The **unbounded dependency definition** also fails to extend to copy raising.

  1. **Lexically governed property of certain verbs**

     - For example, in English only *seem* and *appear* are true copy raising verbs.

     - Other verbs that display superficially similar behaviour (**perceptual resemblance verbs**: *look*, *smell*, *sound*, *feel*, *taste*) in fact do not require a copied pronoun in their complement:

       (42)   Thora smells like someone has been baking bread.

     ⇒ **Copy raising should not be subject to a general mechanism of unbounded dependency formation.**

  2. **Local dependency between syntactic arguments of a particular verb**

     - Cannot long-distance copy-raise across an intervening subject:

       (43)   *Thora thought that I seemed like she had eaten the crackers.

  ⇒ **Copy raising:**

     - **Should not be analyzed in terms of unbounded dependencies**

     - **Should instead be analyzed in terms of lexically-governed raising-type dependencies**

- **Problems with previous proposals for copy raising:**

  1. Copy raising as **A-movement** analog of resumptive pronouns in **A-bar movement** (unbounded dependencies)   (Ura 1998, Boeckx 2003)

     (a) A-movement should not be possible from the site of the copy pronoun.
         (Tensed S Condition, Phases)

  2. Base-generated chain   (Potsdam and Runner 2001)

     (a) Unconstrained

     (b) Chain with two Case positions

     (c) (Treat copy raising and perceptual resemblance verbs on a par)

  3. Both approaches share the problem that they predict copy raising should only be possible from subjects:

     (44)   Judith seemed like the ombudsman had finally decided that she had been in the right.

     (45)   Richard seemed like Emma had scolded him.

     (46)   Richard seems like the assertion by Ida that Thora suspects the motives behind the gift has offended his dignity.

4.2.3 Summary

It is difficult to give a theoretically acceptable definition of resumptive pronouns that:

1. Relates resumptive pronouns to gaps/traces.

2. Properly distinguishes resumptive unbounded dependencies from unbounded dependencies with gaps/traces.

3. Relates resumptive pronouns to copy raising pronouns.

4. Properly distinguishes the relationship between the antecedent and the resumptive in an unbounded dependency from the relationship between the antecedent and the pronoun in copy raising.

4.3   A new perspective

- **Resumption (informal definition)**
  Resumption is the presence of a pronoun that is not required for semantic composition.

- This definition applies equally to resumptive pronouns in unbounded dependencies and copy raising pronouns.

  - Uniform treatment of the two cases

  - Captures differences between the two through the interplay of lexical specifications and the usual mechanisms for anaphoric binding and unbounded dependencies

- In each case:

  - The pronoun's semantic contribution is surplus to the basic compositional requirements of the sentence that it appears in.

  - **But** the pronoun must be consumed by something in order for there to be a successful derivation of the semantics.

- $\Rightarrow$ A resumptive pronoun is only licensed in the presence of a special licenser that consumes the pronoun, removing it from semantic composition: **manager resources**.

- **Resumptive pronouns are ordinary pronouns.**

- **The relationship between the resumptive pronoun and its antecedent is captured through the standard mechanism of anaphoric binding.**

4.4   The theoretical basis for the proposal

- Hypothesis of **Resource Sensitivity**: Natural language is universally *resource-sensitive*.

- **A *resumptive pronoun* is a surplus resource that will lead to failure of semantic composition (proof failure in the linear logic), unless it is consumed by a lexically contributed *manager resource*, which thus licenses the resumption.**
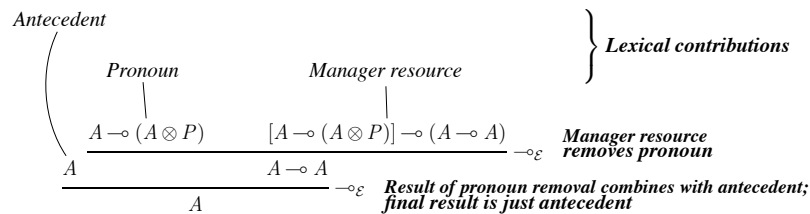

Figure 1: A manager resource removes a pronominal resource

4.5   Theoretical implications and empirical predictions

4.5.1   Implications

1. **Unification**
   A generalized theory of resumption in unbounded dependencies and copy raising

2. **Simplification**
   Syntactically and semantically ordinary pronouns

   (a) The terms *resumptive pronoun* and *copy raising pronoun* are not theoretical constructs, but rather just descriptive labels.

   (b) Resumptive pronouns as such have been eliminated from the theory — ordinary pronouns are all there is.

3. **Lexicalism**
   Pronouns in resumption are licensed by lexically contributed manager resources.

   (a) Resumption is licensed through the presence of lexically-specified licensers in lexical inventories.

   (b) Depending on its lexical inventory:

       - A language may have resumptive pronouns both in unbounded dependencies and copy raising (e.g., Irish, Swedish).
       - A language may have resumptive pronouns in one case and not the other. (e.g., English — only copy raising)
       - A language may have neither kind of resumption (e.g., German).

4. **An answer to the central question about resumption**

   Why are pronouns used for resumption?
   Pronouns are used in resumption because they lack inherent meaning.
   Pronominal meaning is recoverable.

   - The theory ensures that pronouns are the only lexical items that can be consumed by manager resources.

   - $\Rightarrow$ Only pronouns can be used in resumption because they are the only things that have the correct form to be consumed by manager resources.

   - Why do pronouns have this form?

       - Because of how they take their reference based on their antecedent.
       - This gives them a particular form in the logic assumed in the theory.

   - $\Rightarrow$ Pronouns are used in resumption because of how they receive their meanings.

   - Why do pronouns receive their meanings in this manner?

       - Pronouns receive their meanings in the specific manner that they do because they lack inherent meaning and must take on the meaning of their antecedent, through saturation, coreference, or binding.

   - $\Rightarrow$ Pronouns are used for resumption because they lack inherent meaning.

   - $\Rightarrow$ Pronominal elements can be consumed by manager resources because it is precisely these elements whose removal is recoverable from elsewhere in the semantics.

4.5.2 Predictions

General

1. Resumptive pronouns are morphologically identical to non-resumptive pronouns with the same case and agreement features (McCloskey 2002).

2. Resumptive pronouns inherit any general restrictions on pronominal interpretation.
   (Doron 1982, Sells 1984, Sharvit 1999)

3. Given the uncontroversial premise that lexical specification affects morphological exponence, the analysis makes the following further prediction:

   (47)   Resumptive licensers may be distinguished by morphology or lexical class.

   - Irish and Welsh have resumptive-sensitive complementizers that show distinct morphological marking from non-resumptive complementizers and which have distinct morphophonological effects (mutations) on subsequent material (Awbery 1977, McCloskey 1979, Sells 1984, Willis 2000).

     – Irish: *aN* — resumptive pronoun
       aL — gap

   - English copy raising verb are distinguished by lexical class: only a very limited subset of raising verbs allow copy raising (*seem* and *appear*).

Resumption in unbounded dependencies

Unbounded dependencies that end in resumptive pronouns are handled by anaphoric binding. Those that end in gaps are handled by structure-sharing/movement.

4. Unbounded dependencies with gaps may have different properties from those with resumptive pronouns.

   (a) Islands

   (b) Weak crossover

   (c) Form-identity effects

Resumption in copy raising

Copy raising is likewise mediated through anaphoric binding.

5. Copy raising is not limited to targeting subjects.

6. Copy raising and nonfinite raising differ with respect to quantifier scope.

7. Irish copy raising predicted:

   (48)   B'éigean daobhtha **gur**   innis <u>siad</u> an scéal dó.
           must   to.them   COMP told   they the story to.him
           They must have told him the story.
           (McCloskey and Sells 1988: 176, (65c))

   (49)   Ní   cosúil dó   **go**   gcuireann rud   ar birth buaireamh <u>air</u>.
           NEG.COP like   to.him COMP puts   thing any   distress   on.him
           Nothing seems to bother him.
           (McCloskey and Sells 1988: 177, (68a))

The puzzle: *aN* is the resumptive-sensitive complementizer and *go* is the neutral / non-unbounded dependency complementizer.

Why then does copy raising in Irish not feature the complementizer *aN*?

- *aN* licenses resumptives by contributing a manager resource.
- The raising verb licences copy raising by contributing a manager resource.
- Each manager resource must consume a separate pronoun.
- But there is only a single copy pronoun to be consumed.
- ⇒ The non-resumptive/neutral complementizer *go* must be used in copy raising.
  – This is the only option that ensures proper resource accounting.

4.6 Summary

- A generalized theory of resumption
  (based on a resource logical approach to the syntax–semantics interface and semantic composition)

- Other phenomena that test Resource Sensitivity:

  – Resource deficit: coordination, right-node raising, parasitic gaps

  – Resource surplus: finite control

5   Conclusion

- Application of substructural resource logics to linguistics

- Theoretical applications:

  - Proofs and the syntax–semantics interface

  - A logic for feature checking and interpretation ($\mathcal{L}_{fc}$)

  - Resource Sensitivity

- Empirical applications:

  - Generalized theory of resumption (resumptive pronouns, copy raising) based on resource-sensitive semantic composition

- Current and future work:

  - Computational linguistics
    1. Grammar engineering: syntactic and semantic implementations of Persian, others
    2. Computational semantics: proof-theory, composition, context and anaphora

  - Theoretical linguistics:
    1. Applications of proof theory and resource sensitivity to linguistics: proof theory and model theory, feature checking and interpretation
    2. Syntax and semantics of copy raising: expletives, crosslinguistic perspective, perceptual reports, event semantics
    3. Syntax and semantics of raising and control: crosslinguistic perspective on finite varieties

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