

The Logic of Pied Piping

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(1) The Pretheoretical Term ‘Overt Movement’

- In this talk, by **overt movement**, we mean the class of phenomena that have been discussed over the past half-century under such rubrics as **extraction** and **\bar{A} -movement**.
- Thus it refers to phenomena such as those discussed by Chomsky (1977) ‘On wh-movement’ or by Levine and Hukari 2006 (*The Unity of Unbounded Dependency Constructions*).
- So phenomena that have been discussed under the rubrics of **head movement** (e.g. verb inflection, subject-auxiliary inversion) and **NP-movement/A-movement** (e.g. passive, raising to subject) are excluded.
- In English, there are both finite and infinitive overt movement constructions, but for expository simplicity, in this talk we consider only the finite constructions.

(2) Some Examples of Overt Movement

- a. JOHN_i, Fido bit t_i. [Topicalization]
- b. I wonder [who_i Fido bit t_i]. [Indirect Question]
- c. Who_i did Fido bite t_i? [Direct Question]
- d. The neighbor [who_i Fido bit t_i] was John. [Relative Clause]
- e. Felix bit [who(ever)_i Fido bit t_i]. [Free Relative]
- f. It was John [who_i Fido bit t_i]. [Cleft]
- g. [Who_i Fido bit t_i] was John. [Plain Pseudocleft]
- h. [Who_i Fido bit t_i] was he bit John. [Amalgamated Pseudocleft]
- h. [[The more cats]_i Fido bit t_i], [[the more dogs]_j Felix scratched t_j]. [Left and right sides of Correlative Comparatives]

In all these examples, the expression on the left periphery that is coindexed with the trace is called the **filler**, or **extractee**, or **dislocated expression**.

(3) The Pretheoretical Term ‘Trigger of Overt Movement’

- In Topicalization, the trigger is the topic phrase, signaled by a ‘B-accent’ (notated here by SMALL CAPS).
- In Correlative Comparatives (both sides), the trigger is a comparative phrase with the correlative *the* occupying the position normally occupied by a determiner/scalar (e.g. *many, five*).
- In the remaining constructions in (2), the trigger is a *wh*-expression, usually called an **interrogative** or **relative** expression. (In clefts and pseudoclefts, people seem uncertain what to call them.)

The discussion above applies to English, but languages differ with respect to:

- the inventory of trigger types
- which trigger types have similar morphosyntactic exponents, e.g. in English, broadly similar *wh*-expressions are used for questions, relatives, free relatives, and pseudoclefts.

(4) Overt Movement with no Filler

There are also some overt movement constructions where the trigger cannot be identified because there is no filler e.g.

- a. Every neighbor 0_i [Fido bit t_i] called Animal Control. [Relative Clause with no relative word or complementizer.]
- b. Felix scratched more neighbors than 0_i [Fido bit t_i]. [Comparative Deletion]
- c. Felix scratched more neighbors than 0_i [Fido bit t_i mailmen]. [Comparative Subdeletion]

Such constructions have sometimes been analyzed as movement of an **empty operator**, notated here by 0_i .

(5) The Pretheoretical Term ‘Covert Movement’

In this talk, by **covert movement**, we mean the class of phenomena that have been discussed under such rubrics as **movement at LF**, **Quantifier Raising**, **wh-in-situ construal**, or **comparative operator construal**. Examples follow.

- (6) **Covert Move: Quantifier Scope**
 [Some philosopher] loathes [every linguist.]
 ‘There is a philosopher who loathes every linguist.’
 ‘For every linguist, there is a philosopher who loathes him/her.’
- (7) **Covert Move: Wh-*in Situ* in a Language with Overt Move**
 Who asked who ordered what?
 ‘Who asked the question: who ordered what?’
 ‘For which person x and thing y did x ask who ordered y ?’
- (8) **Covert Move: Wh-*in-Situ* in a Language without Overt Move**
 Zhangsan bu-xihuan shei
 Zhangsan not-like SHEI
 ‘Who doesn’t Zhangsan like?’, or
 ‘Zhangsan doesn’t like anyone.’
 Note that Chinese in-situ wh-expressions can be interpreted as either interrogatives or indefinites.
- (9) **Covert Move: Scope of Comparative Operators**
 Mary claimed more _{i} tickets were sold than there are t_j seats.
 ‘Mary claimed that the number of tickets sold was greater than the number of seats.’
 ‘The number of tickets the Mary claimed were sold was greater than than the number of seats.’
 Note that the *than*-clause contains a second, (fillerless, overt) movement, corresponding to the ‘subdeleted’ determiner (notated t_j).
- (10) **The Pretheoretical Term ‘Pied Piping’**
- In all the examples of Overt Movement with a filler we considered above (2), the trigger coincides with the filler.
 - By **Pied Piping**, we mean cases of overt movement where the trigger is a *proper subpart* of the filler.
 - In such cases, the trigger is said to be **pied piped** within the filler.

(11) **Some Rough Generalizations about English Pied Piping**

- Most commonly cited positions for pied-piped triggers include:
 - (within) the object of a preposition
 - the possessive determiner of an NP
 - determiner/degree specifier of a (positive or comparative) gradable expression
 - recursive combinations of the preceding.
- Different kinds of triggers have different options for where they can be within the filler.
- Examples follow (limited to triggers with *wh*-morphology; we postpone Pied Piping in Topicalization and Correlative Comparatives to another day).

(12) **Pied-Piping Options for English *Wh*-Relatives**

- a. The student [to whom]_{*i*} you were speaking *t_i* is here.
- b. The student [whose parents]_{*i*} you called *t_i* is here.
- c. The student [to whose parents]_{*i*} you were speaking *t_i* is here.
- d. The student [whose parents' phone number]_{*i*} you forgot *t_i* is here.
- e. The student [a poem about whom]_{*i*} you wrote *t_i* is here. [Stilted, but still okay.]

(13) **Pied-Piping Options for English Clefts**

- a. It was Mary [to whom]_{*i*} you were speaking *t_i*.
- b. It was Mary [Whose parents]_{*i*} you called *t_i*.
- c. It was Mary [to whose parents]_{*i*} you were speaking *t_i*.
- d. It was Mary [whose parents' phone number]_{*i*} you forgot *t_i*.
- e. It was Mary [a poem about whom]_{*i*} you wrote *t_i*. [Stilted, but still okay.]

(14) **Pied-Piping Options for English *Wh*-Questions**

- a. [To whom]_i were you speaking t_i?
- b. [Whose parents]_i did you call t_i?
- c. [To whose parents]_i were you speaking t_i?
- d. [Whose parents' phone number]_i did you forget t_i?
- e. *[A poem about whom]_i did you write t_i??

(15) **Pied-Piping Options for English *Wh-ever* Free Relatives**

- a. *[To whomever]_i you were speaking t_i is back.
- b. [Whoever's parents]_i you called t_i is back.
- c. *[To whoever's parents]_i were you speaking t_i is back.
- d. [Whoever's parents' phone number]_i you forgot t_i is back.
- e. *[A poem about whoever]_i you wrote t_i is back.

(16) **Pied-Piping Options for English Pseudoclefts**

- a. *[To whom]_i you were speaking t_i was Mary.
- b. *[Whose parents]_i you called t_i was Mary.
- c. *[To whose parents]_i you were speaking t_i was Mary.
- d. *[Whose parents' phone number]_i you forgot t_i was Mary.
- e. *[A poem about whom]_i you wrote t_i was Mary. [Stilted, but still okay.]

(17) **Rough First-Pass Empirical Generalizations**

- Relative and Cleft triggers are 'essentially the same', and have the most options for Pied Piping.
- Pied Piping of *Wh*-Question triggers is somewhat more constrained than of *Wh*-Question triggers (cf. (14) vs. (12)).
- *Wh-ever* Free Relative triggers cannot be pied-piped to object of preposition position.
- Pseudocleft triggers cannot be pied-piped at all.

(18) **Some Pretheoretic Analytic Intuitions for English**

- Pied-Piped triggers are *in situ* relative to the fillers that contain them.
- Relative/Cleft, Free Relative, Question, and Pseudocleft are different ‘flavors’ or ‘modes’ of Covert Movement.
- In particular: *whose* is ambiguous between a Question trigger and a Relative trigger. (In this connection, note that relative *whose* can be inanimate, interrogative *whose* cannot.)
- And *who* is four-ways ambiguous between a Question trigger, a Relative trigger, a Free Relative trigger, and a Pseudocleft trigger.

(19) **Starting to Get Theoretical: The Gist of CVG**

- As in much recent ‘Curryesque’ type-theoretic grammar (ACG, GF, HOG, etc.) we will analyze linguistic expressions as ordered triples of (Curry-Howard terms for) derivations: Prosodies, Syntax, and Semantics (though we’ll ignore Prosodies here, for expository simplicity).
- But following HPSG and a few others (Jackendoff, Culicover, Lecomte and Retoré), we reject *syntactocentrism* and treat Syntax and Semantics as *parallel*.
- This sets CVG apart from both the transformational (‘Syntax is transformed into LF’) and categorial (‘Syntax is mapped to Semantics’) traditions.

(20) **Some Consequences of Parallelism**

- There can be prosodic effects that correspond to no syntactic or semantic distinction. Possible candidates:
 - particle ‘movement’
 - clitic ‘climbing’,
 - ‘extraposition’ of PPs, relative clauses, and *than*-clauses)
 - PP ordering, e.g. *talk about it with him/talk with him about it*
- And there can be semantic ambiguities that correspond to no syntactic or prosodic distinction, e.g.

- choice of antecedent for bound pronoun
- scope of quantifiers, comparatives, and *wh-in situ*
- The latter point is directly influenced by various suggestions in the 1970s-1980s to ‘relax compositionality (e.g. Cooper, Bach and Partee, Partee and Rooth, H. Hendriks).

(21) **The Gist of the CVG Theory of Overt Movement**

- Like many others (from mid-1970s on), we treat Overt Movement as (simulated) abstraction/hypothetical proof. [E.g. Cooper’s, or Bach and Partee’s, storage; Gazdar’s derived rules; Steedman’s successive composition; Moortgat (I think) was the first to give an explicitly hypothetical-proof formulation.]
- Overt Movement involves *parallel* syntactic/semantic hypotheses (i.e. trace and the corresponding ‘LF variable’ are side-by-side), which are simultaneously bound by (prosodically vacuous) syntactic and semantic lambdas.
- The derivations are *not* ‘structures’ whose ‘parts’ can be moved around.
- The filler never occupied the trace position.
- CVG does *not* aim to logically reconstruct Minimalism; it is in a tradition that parted company with TG 30 years ago.

(22) **The Gist of the CVG Theory of ‘Operator Binding’**

- Many kinds of expressions (quantificational NPs, topics, foci, comparatives, interrogatives, (cor-)relatives, etc.) have ‘delayed’ meanings that are ‘remembered’ together with a semantic variable.
- Later in the *semantic* derivation, that variable is discharged and the resulting abstract is combined with the ‘remembered’ meaning.
- Depending on the language and the kind of operator, there are two options for how this comes about:
 - the operator might be ‘globally *in situ*’, i.e. never has any connection with Overt Movement; or

- it might be (within) a filler, and is interpreted at the point in the derivation where the filler combines with the Overt Movement abstract. [In this case, the operator is traditionally thought of as the ‘movement trigger, but that term is extremely misleading!]

(23) **The Convergent Grammar (CVG) Framework**

CVG is an attempt to synthesize a unified and formally explicit framework from these ideas. The key ones:

- Syntax and semantics (and phonology/prosody) are **parallel dimensions** of language.
- More specifically, they can be seen as **parallel natural-deduction proofs**, or equivalently, **tuples of Curry-Howard proof terms**.
- On the syntax side, the proofs/terms can be thought of as rough analogs of EST (1970s-style TG) s-structures (complete with traces and binding by empty operators).
- On the semantics side, the proofs/terms are an upgraded version of the semantic lambda terms of Montague’s IL or Gallin’s Ty2.

(24) **A CVG Generates Ordered Pairs of Derivations**

[Really, it generates ordered triples, but we’re ignoring phonology/prosody.]

- The syntactic derivation is represented by a (Curry-Howard) proof term for a multimodal resource-sensitive logic where:
 - the nonlogical axioms are the syntactic words;
 - the hypotheses are the traces;
 - the (different modes of) application are the merges; and
 - the lambdas are the empty operators that bind the traces.
- The semantic derivation in the pair is represented by a (Curry-Howard) proof term in a lambda calculus broadly similar to Montague’s IL or Gallin’s Ty2.

More specifically, it is a term of a certain (hyperintensional) semantic theory written in a certain kind of higher order logic.

(25) **CVG Notation, First Pass**

To express that a certain syntactic-semantic pair of derivations is licensed by the grammar, we write:

$$\vdash a, b : A, B \dashv$$

This says the pair of a and b is licensed, where a has the syntactic category A and b has the (hyperintensional) semantic type B .

(26) **CVG Notation, Second Pass**

More generally, we write:

$$\Gamma \vdash a, b : A, B \dashv \Delta$$

to express that the grammar licenses a certain syntactic-semantic pair of derivations *modulo* certain syntactic-semantic paired hypotheses (unbound traces) Γ and certain purely semantic hypotheses Δ ‘remembered’ together with certain ‘delayed’ semantic operators.

(27) **Some CVG Lexical Entries (Phonology Omitted)**

$$\vdash \text{that}, \lambda_p p : \text{Fin} \dashv_{\circ_M} \bar{S}, \text{Prop} \supset \text{Prop} \dashv$$

$$\vdash \text{Fido}, \text{Fido}' : \text{NP}, \text{Ind} \dashv$$

$$\vdash \text{barked}, \text{bark}' : \text{NP} \dashv_{\circ_{\text{SU}}} \text{Fin}, \text{Ind} \supset \text{Prop} \dashv$$

$$\vdash \text{bit}, \lambda_y \lambda_x \text{bite}'(x, y): \\ \text{NP} \dashv_{\circ_C} (\text{NP} \dashv_{\circ_{\text{SU}}} \text{Fin}), \text{Ind} \supset (\text{Ind} \supset \text{Prop}) \dashv$$

$$\vdash \text{gave}, \lambda_{y,z} \lambda_x \text{give}'(x, y, z): \\ (\text{NP} \circ \text{NP}) \dashv_{\circ_C} (\text{NP} \dashv_{\circ_{\text{SU}}} \text{Fin}), (\text{Ind} \wedge \text{Ind}) \supset (\text{Ind} \supset \text{Prop}) \dashv$$

$$\vdash \text{believed}_1, \lambda_p \lambda_x \text{believe}'(x, p): \\ \text{Fin} \dashv_{\circ_C} (\text{NP} \dashv_{\circ_{\text{SU}}} \text{Fin}), \text{Prop} \supset (\text{Ind} \supset \text{Prop}) \dashv$$

$$\vdash \text{believed}_2, \lambda_p \lambda_x \text{believe}'(x, p): \\ \bar{S} \dashv_{\circ_C} (\text{NP} \dashv_{\circ_{\text{SU}}} \text{Fin}), \text{Prop} \supset (\text{Ind} \supset \text{Prop}) \dashv$$

(28) **How CVG Rules Work**

- Each rule combine lexical entries (themselves pairs of derivations) and other pairs of derivations already built up from other rules, to form more complex pairs of derivations.
- Each time a rule is used, the resulting pair of derivations inherits all the hypotheses and delayed operators from its immediate-constituent pairs, *except* for ones that are explicitly discharged by the rule.
- Each rule specifies the data structures for storing the inherited hypotheses and delayed operators, and the orders in which these things are stored.
- There is nothing corresponding to syntax being transformed into, or mapped to, semantics.

(29) **Some CVG Rules**

Fusion:

If $\Gamma \vdash a, c : A, C \dashv \Delta$ and $\Gamma' \vdash b, d : B, D \dashv \Delta'$
then $\Gamma; \Gamma' \vdash a \cdot b, (c, d) : A \circ B, C \wedge D \dashv \Delta; \Delta'$

Subject Merge:

If $\Gamma \vdash a, c : A, C \dashv \Delta$ and $\Gamma' \vdash f, v : A \dashv_{\text{su}} B, C \supset D \dashv \Delta'$
then $\Gamma; \Gamma' \vdash (^{\text{su}} a f), v(c) : B, D \dashv \Delta; \Delta'$

Object Merge:

If $\Gamma \vdash f, v : A \dashv_{\text{c}} B, C \supset D \dashv \Delta$ and $\Gamma' \vdash a, c : A, C \dashv \Delta'$
then $\Gamma; \Gamma' \vdash (f a^{\text{c}}), v(c) : B, D \dashv \Delta; \Delta'$

(30) **More CVG Rules**

Trace:

$t, x : A, B \vdash t, x : A, B \dashv$

Overt Move:

If $t, x : A, B; \Gamma \vdash s, p : \text{Fin}, \text{Prop} \dashv \Delta$
then $\Gamma \vdash \lambda_t^{\text{SL}} s, \lambda_x p : A \dashv_{\text{SL}} \text{Fin}, B \supset \text{Prop} \dashv \Delta$

Topicalization:

If $\Gamma \vdash a, b : A, B \dashv \Delta$ and $\Gamma' \vdash c, d : A \dashv_{\text{SL}} \text{Fin}, B \supset \text{Prop} \dashv \Delta'$
then $\Gamma; \Gamma' \vdash \tau(a, c), d(b) : \text{Top}, \text{Prop} \dashv \Delta; \Delta'$

(31) **A Topicalization Example**

- a. Felix, Fido bit.
- b. $\vdash \tau(\text{Felix}, \lambda_t^{\text{SL}}(\text{Fido}_n (\text{bit } t^c)))$, bite'(Fido', Felix') : Top, Prop \dashv
- c. In the syntax, different modes of Merges (Modus Ponens) are represented by superscripted parentheses.
- d. (Overt) Move is represented by the SL (SLASH) mode of lambda abstraction (Hypothetical Proof).
- e. Syntactically, Topicalization itself (represented by τ) is a non-logical proof rule (not a Modus Ponens).
- f. As shown, the semantic component of Topicalization *is* Modus Ponens; that is a temporary simplification (pending an explicit theory of the information-structural significance of contrastive topics).

(32) **Multiple In-Situ WH-Questions in Chinese**

- a. Zhangsan xiang-zhidao shei mai-le shenme.
- b. Zhangsan wonder who buy-ASP what
- c.
 - i. 'Zhangsan wonders who bought what.'
 - ii. 'Who does Zhangsan wonder what (that person) bought?'
 - iii. 'What does Zhangsan wonder who bought?'

(33) **Analysis of Chinese Interrogative Expressions**

$\vdash \text{shei}, x : \text{NP}, \text{Ind} \dashv \text{QUE}:(x, \text{person}')$

$\vdash \text{shenme}, y : \text{NP}, \text{Ind} \dashv \text{QUE}:(y, \text{thing}')$

(34) **A Chinese Covert Movement Rule**

QUE-*in situ* Construal:

If $\Gamma \vdash s, p : \text{Fin}, \text{Prop} \dashv \Delta[\text{QUE}:\Sigma; (x_1, f_1), \dots, (x_n, f_n)]$ then

$\Gamma \vdash s, \text{which}'_{x_1, \dots, x_n}(f_1(x_1) \text{ and}' \dots \text{and}' f_n(x_n), p) :$

$\text{Fin}, \text{Prop} \supset \text{Prop} \dashv \Delta[\text{QUE}:\Sigma]$

Note 1: in this rule, the f_i are the semantic properties associated with the *in situ* interrogative expressions.

Note 2: **which'** abbreviates a certain (parametrically polymorphic family of) hyperintensional semantic term(s). For details (and the explanation of why the semantic terms for interrogative sentences really are interpreted model-theoretically as questions), see Pollard 2007c.

(35) **Analysis of the Chinese Examples**

a. The grammar licenses three different analyses (derivation pairs).

b. All three have the same syntactic derivation:

$(^{\text{SU}} \text{Zhangsan} (\text{xiang-zhidao} (^{\text{SU}} \text{shei} (\text{mai-le shenme} ^{\text{C}}) ^{\text{C}}) ^{\text{C}})) :$
 Fin

c. Each has a different semantic derivation:

i. $\text{wonder}'(\text{Zhangsan}', \text{which}'_{x,y}(\text{person}'(x) \text{ and}' \text{thing}'(y), \text{buy}'(x, y))) :$
 Prop

ii. $\text{which}'_x(\text{person}'(x), \text{wonder}'(\text{Zhangsan}', \text{which}'_y(\text{thing}'(y), \text{buy}'(x, y)))) :$
 $\text{Prop} \supset \text{Prop}$

iii. $\text{which}'_y(\text{thing}'(y), \text{wonder}'(\text{Zhangsan}', \text{which}'_x(\text{person}'(x), \text{buy}'(x, y)))) :$
 $\text{Prop} \supset \text{Prop}$

Note that the type $\text{Prop} \supset \text{Prop}$ ('proposition into proposition', i.e. propositional property) is the (hyperintensional) semantic type for questions.

(36) **English WH-Questions, Pretheoretically**

- In English, an interrogative operator can be (globally) *in situ*, but it can also be (in) a filler.
- However, with certain pragmatically marked exceptions, *in situ* interrogative operators can take scope only together with one that is in the filler that ‘c-commands’ them.
- The formal rule that expresses this will be like a combination of the English Topicalization rule and the Chinese QUE-*in situ* Construal rule, with the proviso that the filler has to contain at least one delayed interrogative operator (in oldthink, the movement trigger).

(37) **An English WH-Question Rule**

If $\Gamma \vdash a, b : A, B \dashv \text{QUE}:(x_0, f_0)$

and $\Gamma' \vdash c, d : A \dashv_{\text{SL}} \text{Fin}, B \supset \text{Prop} \dashv \Delta'[\text{QUE}:(x_1, f_1), \dots, (x_n, f_n); \Sigma]$

then $\Gamma; \Gamma' \vdash \kappa(a, c)$, **which'** _{x_1, \dots, x_n} ($f_0(x_0)$ **and'** ... **and'** $f_n(x_n)$, $d(b)$) : $\text{Q}, \text{Prop} \supset \text{Prop} \dashv \Delta'[\text{QUE}:\Sigma]$

Note 1: Purely for notational convenience, we make the simplifying assumption that the ‘movement trigger’ is the only delayed operator in the filler.

Note 2: Here Fin is the syntactic category for finite declarative sentences, and Q is the syntactic category for embedded interrogative sentences.

(38) **An English Embedded, Pied-Piped Multiple Wh-Question**

a. to whom John spoke about what

b. Syntactic derivation:

$\kappa((\text{to whom } ^c), \lambda_t^{\text{SL}}(\text{SU John (spoke } (t \circ (\text{about what } ^c)) ^c)))$

c. Semantic derivation:

which' _{x, y} (**person'**(x) **and'** **thing'**(y), **spoke'**(**John'**, **to'**(x), **about'**(y)))

Note 1: the analysis assumes a lexical entry for *spoke* that subcategorizes for a *to*-PP and an *about*-PP.

Note 2: the interpretations of the prepositions are identity functions.

Note 3: κ is the nonlogical term constructor for the syntactic component of the rule.

CVG/Hyperintensional Semantics References

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