On Possible Variables and Impossible Grammars

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1. Introduction.

A central goal of generative linguistics is to characterize what a **possible** grammar of a natural language is; of all the grammars one could imagine, only some are actually attested as natural language grammars. To this end, universals are proposed (sometimes initially in the form of descriptive statements, with the further question of how to incorporate them into a theory of Universal Grammar.)

Support for universals from acquisition studies? Smith & Tsimpli (1995).

My talk today concerns what a possible **variable** is in natural language grammars. Specifically, I will suggest that variables range only over **individuals**, so that the following constraint holds (see also Chierchia 1984 and Baker 2003):

(1) *The Restricted Variables Constraint* (RVC)
Variables range only over individuals.

To understand this constraint, we need to understand:

-What variables are (and which expressions are variable denoting);
-What individuals are (and what counts as an individual).

Variables are commonly used to model the meanings of two types of linguistic expressions: pro-forms and movement gaps. My claim is that the RVC constrains the inventories of both of these kinds of expressions.

The plan for today:

-Clarify the constraint and its predictions;
-Present empirical support;
-Speculate (a little) on why it should hold.

I find this constraint particularly interesting in that it is very easy to imagine a grammar in which variables do **not** range only over individuals. In fact, it is more the norm for semantic systems to permit variables that range over any semantic type. If this constraint holds, it makes for an interesting way in which natural language grammars may be unlike imaginable, but unattested, artificial language grammars.

2. Variables and variable-denoting expressions. Certain expressions clearly vary in meaning (or **denotation**). Consider, for example the meaning of a pronoun:

(2) a. She's crazy. b. It's a mess.

Pronouns can pick out different individuals depending on the context (linguistic or non-linguistic) in which they occur; they in this way contrast with e.g. proper names, which are stable in meaning, and cannot refer back to another noun phrase.

To account for their variation in meaning, pronouns can be modeled as **variables**: they depend for their denotation on a choice of an assignment of a value.

Take, for example, the denotation for *she* in (3). I assume that *she* is associated syntactically with an index, *i*, and that the interpretation function, [[ ]], is relativized to an assignment function, *a*, which maps *i* to some particular individual in the domain of individuals (D).

(3) $[[she_i]]^a = a(i)$

The upshot: *she* (and third person pronouns more generally) denote whatever invidual the assignment maps their index to. Assignments can vary depending on the utterance situation, so that different assignments can assign different individuals to different indices.

I take variables, then, to be those LF expressions that receive their denotation solely from an assignment function, i.e., indices in the syntactic representation.

The proposed constraint can be implemented by restricting the domain of the variable assignment to D; in effect, object language variables necessarily denote in D.

Terminology: Whereas pronouns are *variables*, proper names are *constants*.

3. What counts as an individual? Inventory of pro-forms in English.

same meaning
range = vary

The claim: Variables range only over individuals.
Next step: Make clear what is and is not an individual.

While proper names and pronouns differ in that only the latter are variables, they are alike in that they both denote individuals. But not all expressions denote individuals.

I take the domain of individuals to include:

Objects (i.e., people, things, and places):

(4)	a. *Sabina* fell.	b. *She* fell.	*people*
(5)	a. *The ship* sank.	b. *It* sank.	*things*
(6)	a. *Ghana* is a country.	b. *It* is a country.	*places*

Plural individuals, i.e. entities formed from two or more individuals (Link 1983):

(7)	a. *Ruben and Becky* danced.	b. *They* danced.	*plural objects*

Locations, *times*, *degrees*, and *manners* (cf. Schwarzschild & Wilkinson 2002, Bale 2006).

(8)	a. He put it *on the table*.	b. He put it *there*.	*locations*
(9)	a. He called *at midnight*.	b. He called *then*.	*times*
(10)	a. He grinned *wildly*.	b. ?He grinned *so/thus*.	*manners*
(11)	a. He is *six-feet* tall.	b. He is *that* tall.	*degrees*

What DOESN'T the domain of individuals include?

Expressions that **do not** denote individuals include quantificational noun phrases:

(12) No man confessed.
(13) Every man confessed.

No man is said to be of a different **semantic type** than proper names and pronouns. In particular, quantificational noun phrases are commonly interpreted as **generalized quantifiers** (Montague 1974, Barwise and Cooper 1981, Mostowski 1957).

Spelling out what it means to be a generalized quantifier

I assume a truth-conditional, compositional semantics according to which:

(i) Sentences are paired with their truth-conditions;
(ii) The meaning of an expression is determined by the meanings of its parts, and the way in which those parts are assembled syntactically;
(iii) Set-theoretic entities are posited to model the meanings of expressions.

E.g. (12) is true iff the set of individuals that are men is disjoint from the set of individuals that confessed. Implicit in this is the idea that common nouns like *man* and verb phrases like *confessed* denote sets of individuals. The semantic contribution of *no*, then, is to require that those two sets be disjoint. Building on this, we can say that *no man* denotes a certain set: the set of sets that are disjoint from the set of individuals that are men. For the whole sentence to be true, the VP, *confessed*, must be a member of this set.

Summarizing, linguistic expressions can be categorized into at least three different semantic types: individuals, sets of individuals, and sets of sets of individuals:

(14)	Expression	Semantic type	Type name
	Sabina, she	Individual	Individual
	man, confessed	Set of individuals	Property
	no man, every man	Set of sets of individuals	Generalized Quantifier

The RVC predicts, then, that variables cannot range over higher-types such as generalized quantifiers or properties. With respect to properties, this prediction is complicated by the fact that some properties - but not all! - correspond to individuals (Chierchia 1984, Chierchia and Turner 1988); we will return to this!

Showing that this holds for generalized quantifiers meanings: We've already seen that pronouns can co-refer with proper nouns:

(15) Ruben thinks that he_i will confess. Semantic structure: Ruben thinks g(i) will confess.

In other words, (15) can mean the same thing as:

(16) Ruben thinks that Ruben will confess.

A very simple theory of pronouns would take them to always denote the same thing as their antecedent. However, it has long been recognized that this can't be right. Consider for example cases in which a quantificational noun phrase antecedes a pronoun:

(17) $[\text{No man}]_i$ thinks that he_i will confess.
(18) $[\text{Every man}]_i$ thinks that he_i will confess.

For these cases, pronouns do not denote the same thing as their antecedents, i.e., we do not get the following readings:

(19) No man thinks that no man will confess.
(20) Every man thinks that every man will confess.

Rather, we can get the right truth-conditions for these sentences by treating these pronouns as *bound variables*:

(21) $\{x \mid x \text{ is a man}\} \cap \{x \mid x \text{ thinks } x \text{ will confess}\} = \varnothing$
(22) $\{x \mid x \text{ is a man}\} \subseteq \{x \mid x \text{ thinks } x \text{ will confess}\}$

Importantly, for these bound variable interpretations, the variables range over individuals. What is not possible is a reading in which a pronoun **co-refers** with (denotes the same thing as) a quantificational NP.

Note that while it could just be a fact about personal pronouns that they range only over individuals, it's easy to imagine a hypothetical pronoun -- call it *zyx* -- which **could** co-refer with a quantificational DP:

(23) Every man thinks that zyx_i will confess.

But no such pronoun exists in English. Pronouns that co-refer with quantificational NPs seem to be systematically missing. Would such pronouns be reasonable? Sure, why not:

(24) At least five dogs and more than three cats had fleas, and at least five dogs and more than three cats had ticks.

(25) At least five dogs and more than three cats had fleas, and *zyx* had ticks.

It is also noteworthy that pronouns ranging over generalized quantifiers are absent, given that such variables have been posited to account for scope reconstruction:

(26) Everyone doesn't agree with the decisions I've made. (George W.)
a. Everyone is such that he/she does not agree with the decisions I've made.
b. Not everyone agrees with the decisions I've made.

Higher-type variables have been proposed to account for the (b) reading (Sharvit 1999, Sternefeld 2001, among others), as a moved item is interpreted as if it were in its base-position whenever its trace matches its type.

(27) $\text{Everyone}_{\langle\langle e,t\rangle,t\rangle}$ I doesn't $t_{1,\langle\langle e,t\rangle,t\rangle}$ agree with the decisions I've made.

Evidence from Binding Theory has independently been argued against this type of analysis (Lebeaux 1991, Heycock 1995, Sportiche 1996, 2001, Romero 1997, Fox 1999, 2000).

What besides generalized quantifiers are of a higher-type?

Certain adverbials do not denote individuals (Chierchia 1984):

(28) a. Becky wrote *again*. b. *Becky wrote *zyx*.
(29) a. Becky wrote *too*. b. *Becky wrote *zyx*.

Cf. (8)-(11) above.

'Functional' or 'grammatical' elements such as determiners, complementizers, conjunctions, etc. do not denote individuals:

(30) *Ruben fed *every* dog, and Becky fed *zyx* cat.
(31) *Ruben likes red *and* pink, and Becky likes blue *zyx* green.

These cases would be ruled out by the proposed constraint.

4. Candidate Counterexamples: Property Pro-forms. What about properties? Some candidate counterexamples:

(32) Ruben will *start laughing*, and then you will *do that*, too. *VP*
(33) *Weird* people... few *such* people... *AP*
(34) He grinned *wildly*... ?Sam danced *so*. *AdvP*

My explanation: Variables in these cases do range over individuals: the individual counterparts of these properties. Spelling this out:

-Some, but not all, properties have **individual counterparts** (Chierchia 1984, 1995).
-The individual counterpart of a property is called a **kind**.
-Variables may range over kinds, and in doing so appear to range over properties.
-Variables cannot range over properties that do not correspond to kinds.
-Which properties correspond to kinds is predictable independent of the facts with respect to variables.

4.1 VP Pro-forms: *Do that*. Some properties have *individual counterparts*. For instance, consider the property *is nice*. Used as a tensed predicate, it denotes a set:

(35) Joe is nice. (Chierchia 1984)

However, properties can be *nominalized*. For example, used as a subject – a gerund, for example – *is nice* may denote an (abstract) individual:

(36) Being nice is nice. (Chierchia 1984)

The individual counterpart of a property is called a *kind* (Chierchia 1984, 1995). Some properties do *not* have individual correlates, that is, they may *not* be nominalized. 'Tensed VPs', for example, may *not* occur as subjects:

(37) *Is nice is nice. (Chierchia 1984)

the guy; that I talked to $\begin{bmatrix} t_i \\ him_2 \end{bmatrix}$

Variables, Trist are in free variation

That properties must be nominalized to be varied over is, I believe, reflected in the shape of VP pro-forms, which are morphologically complex, composed of main verb *do* plus a pro-form *that*, *it*, or *so*:

(38) a. Ruben will *start laughing*, and then
b. ...you will *do that/it/so* too.

Correspondingly, variables may not range over 'tensed VPs':

(39) *Ruben *is laughing*, and Sara *zyx* too.
(40) *Ruben *will start laughing*, and Sara *zyx* too.

The upshot: variables can range over kinds, i.e., nominalized properties.

4.2 AP Pro-forms: *Such*. A similar example is provided by *such*, which superficially appears to range over properties, but arguably only can only range over kinds (Carlson 1977).

(41) *Funny* people... few *such* people... (Carlson 1977b)

Before looking further at *such*, it will be useful to first set aside a use that I will not be concerned with here. *Such* is often ambiguous between a *degree* reading and a *kind* reading (Bolinger 1972, Bresnan 1973):

(42) Hilda is such a scholar. (Bresnan 1973)
a. Hilda is a scholar like that/Hilda is that kind of scholar.
b. HIlda is very much a scholar/Hilda is a great scholar.

On one reading, (42) might be paraphrased as 'Hilda is that kind of scholar', and on a second reading, as 'Hilda is very much a scholar'. Following the terminology of Bresnan (1973), I will refer to the first use of *such* as *kind such*, and the second as *degree such*. I will for the most part only be concerned with kind *such* here, since that is the use on which *such* acts like an adjectival pro-form.

Such has the distribution of a prenominal AP, and at first sight appears to co-refer with a property (Carlson 1977b, Siegel 1994):

(44) a. *Old* people... few *such* people... (Carlson 1977b)
b. Cats *without tails*... several *such* cats...
c. People *who eat fish*... most *such* people...
d. People *owning dogs*... few *such* people...

But *such* cannot co-refer with just any property. In particular, *such* cannot stand in for properties that do not constitute a kind (Carlson 1977b):

(45) a. I know people *in high positions*.
b. *Such* people are good to know.

(46) a. I know people *in the elevator right now*.
b. *#Such* people are good to know.

(47) a. I found quarters *made of silver*.
b. *Such* quarters are good to find.

(48) a. I found quarters *I thought I had put in the meter this morning*.
b. *#Such* quarters are good to find.

A set of individuals that can't be associated with a sufficiently lawlike behavior does not easily correspond to a kind (although this is somewhat context dependent). Thus, a set that picks out a set of things that exist at a certain time in a given place does not easily correspond to a kind.

(46), for example, is only good if *such* picks up the reference of some contextually salient kind that the people in the elevator right now happen to share. The bare plurals in (46a) and (48a) do not easily denote kinds, as their incompatibility with predicates that require a kind shows:

(50) a. People in high positions are common.
b. ??People in the elevator right now are common.

(51) a. Quarters made of silver are rare.
b. ??Quarters that I put in the meter yesterday are rare.

These facts can be accounted for if *such* ranges over kinds. *Such*, then, does not vary over properties, but over kinds, which are construed here as individuals (Carlson 1977, Krifka et al. 1995, and references therein.)

A similar argument can be made for the manner adverbial pro-forms *so* and *thus* (Landman & Morzycki 2003).

4.3 Adverbial Pro-forms: *So*. *So* may be anaphoric to a manner adverbial:

(52) Sam danced *wildly*, and Sam danced *so*.

But what exactly is a manner? In a number of languages, there is a close correspondence between adverbials that are anaphoric to a manner, and expressions that are

analogous to *such*.[1] As adverbials, they are anaphoric to a manner (see also Kehler & Ward 1999 for a similar adverbial use of *so* in English):

(53) a. POLISH
On tańczył tak.
He danced so
'He danced like that.'

b. GERMAN
Er hat so getanzt.
He has so danced
'He danced like that.'

As adnominals, they are analogous to English *such*:

(54) a. POLISH
Taki pies uciekł wczoraj w nocy.
such dog ran.away yesterday in night
'Such a dog ran away last night.'

b. GERMAN
So ein Hund lezte Nacht davongelaufen.
So a dog last night away-ran
'Such a dog ran away last night.'

We find similar correspondences in English:

(56) a. Such a dog ran away last night.
b. ??John danced so.

The relation between the adnominal and adverbial uses can be captured by analyzing them both as variables over *kinds*; event-kinds in the case of adverbials (on event-kinds, see also Hinrichs 1985 and Barwise and Perry 1983). The upshot is that manner is modeled as an event-kind, and manner adverbial pro-forms vary over kinds.

5. Movement Gaps as Variables. Pro-forms are not the only type of expression that variables are used to interpret; *wh*-movement gaps are also often interpreted as variables. Consider, for example, the relative clause construction in (57). I assume that relative clauses are CPs, and within a relative clause, a *wh*-phrase moves to the front of CP, leaving a trace in its original position:

(57) I met the guy [$_{CP}$ who$_i$ Lara lives with t_i].
(58) I met the guy [$_{CP}$ ~~wh$_i$~~ that Lara lives with t_i].

[1] This parallel occurs in a similar form in Macedoninan (Slavica Kochovska, p.c.), Korean (Seunghun Lee, p.c.) and Chinese (Wei Li, p.c.).

Like a pronoun, the gap is interpreted as a variable. This variable is bound by the moved *wh*-operator, which introduces lambda abstraction, creating a set of individuals:

(59) λx . Lara lives with x

If we look at the kinds of variables that may be abstracted over in the position of the gap as the result of movement, the same restrictions seem to hold as were observed for pro-forms.

For instance, as with pro-forms, only certain types of *wh*-constructions are possible. *Wh*-constructions with gaps that have the distribution of locative, temporal, or manner adverbials are possible:

(60) a. He put the glass on the table.
b. Where$_i$ did he put the glass t_i?
c.She put the glass where$_i$ he put it t_i.

(61) a. They left at midnight.
b. When$_i$ did they leave t_i?
c. She fell asleep when$_i$ they left t_i

(62) a. He walks kinda bouncy.
b. How$_i$ does he walk t_i?
c. He walks how$_i$ he dances t_i.

Assuming that *wh*-constructions involve abstraction over a variable in the position of the gap, in (60)-(62), the variable abstracted over may be construed as ranging over individuals -- locations, times, and, event-kinds, adopting the analysis of Landman & Morzycki (2003), by which *manner* is modeled as an event-kind. *Wh*-constructions with gaps that have the distribution of adverbials such as *again* or *too* are *not* possible (see Chierchia 1984 for the roots of this generalization):

(63) a. They attacked again.
b. *How$_i$/when$_i$/where$_i$ did they attack t_i?
c. *They attacked how$_i$/when$_i$/where$_i$ he did t_i.

(64) a. He cried too.
b. *How$_i$/when$_i$/where$_i$ did he cry t_i?
c. *He cried how$_i$/when$_i$/where$_i$ she did t_i.

In (63)-(64), it is hard to see how the variable abstracted over could be construed as ranging over individuals, as it is hard to see how the denotation of *again* could correspond to an individual.

Similarly, VP gaps are not possible in restrictive relative clauses or *wh*-questions, (66), unless nominalized, (67):

(65) I made him [$_{VP}$ wash the dishes].

(66) a. *He washed the dishes [$_{CP}$ ~~wh~~$_i$ that I made him t_i].
b. *What$_i$ did you make him t_i?

(67) a. The washing [~~wh~~$_i$ that I made him do t_i] was gratifying.
b. What$_i$ did you make him do t_i?

The absence of *wh*-constructions with VP gaps is expected given RVC: these constructions would require abstraction over properties. Instead, these examples involve abstraction over nominalized individual variables.

Non-restrictive relatives, *do* allow for gaps that correspond to VPs (Sells 1985, Hardt 1993, Potts 2002ab):

(68) Stop reading my livejournal, which I know you are __.
(69) ??He stopped reading my livejournal, which I made him __.

However, it is not clear that these structures involve variable abstraction, rather than conjunction and ellipsis (contra Potts 2002ab).

6. Main points

-Certain hypothetical pro-forms and movement gaps are systematically absent;

-My proposal: This is a reflection of RVC, which requires that variables range only over individuals, including: people, things, places, plural objects, locations, times, kinds, events, and event-kinds, and degrees.

-While RVC makes very restrictive predictions about the inventory of possible variable-denoting expressions, these restrictions appear to hold for the cases we have looked at in English.

-This might differentiate possible grammars from impossible grammars.

-This might say something about what kinds of things we keep track of in discourse and memory.

Appendix: Previous Approaches

Chierchia (1984) makes a very similar proposal (his *No Functor Anaphora* constraint). By his account, variables may range over individuals or predicates, but not functors:

> "Saying there are no variables of a certain logical type amounts to saying that we cannot refer to arbitrary entities of that type… Our system predicts that functors do not enter anaphoric processes… Hence, we should expect that pronominalization, VP-deletion, *wh*-movement etc. never involve determiners, prepositions, adverbials, etc. It seems to me that there is something basically right about this. For instance, in general determiners, prepositions, complementizers, etc. do not undergo *wh*-movement and have no pro-forms…"

> "Items that might constitute a serious problem for the present hypothesis are obviously adverbs. Adverbs seem to enter various anaphoric processes such as wh-movement or comparative formation, and to have proforms (*thus*, *so*)..."

It is unclear from the wording of his constraint whether the two proposals make different predictions. On one interpretation of his analysis, his proposal permits property variables, which would make my proposal more restrictive.

On a second interpretation, our proposals may make the same predictions, since it is unclear whether the intent of his proposal was to include or rule out variation over properties that do not correspond to individuals.

In the case that the two proposals make the same empirical predictions, this work can be seen as providing further empirical evidence for his original claim by thoroughly looking at the inventories of variable-denoting expressions.

Baker (2003) proposes that only nominals may be anaphoric:

> "I therefore predict that there should be no such thing as "pro-adjectives" or "pro-verbs" in languages of the world that take part in anaphoric relationships with APs and VPs in the same way that pronouns enter into anaphoric relationships with NPs. Prima facie, this seems to be true: virtually every grammar has an index entry for pronouns, but very few mention pro-adjectives or pro-verbs. It is also perfectly possible to work on a language like Mohawk or Edo hard for more than five years and never encounter anything one is tempted to analyze in this way. (Edo is rich in proverbs, but that is another story.)" [Baker 2003, p. 129]

However, the existence of PP pro-forms like *there* call into question his version of the constraint.

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