There is a puzzle regarding the semantics of quantification that is well-known among linguists and formal semanticists, but which has received relatively little attention from philosophers. The puzzle emerges most naturally if our semantic theory is *categorical*, satisfying two mutually supporting requirements:

1. All expressions are assigned semantic values drawn from a type hierarchy recursively built off of a base of two categories of $e$ (objects) and $t$ (truth values) via a generating procedure which specifies that given any two categories $\alpha$ and $\beta$, there is a category $<\alpha, \beta>$ consisting of all functions from members of $\alpha$ to members of $\beta$.

2. The semantic value of a complex expression formed syntactically via combination of two component expressions is the result of functional application of the semantic value of one of these two to the semantic value of the other. (A consequence of these two requirements is then that the syntax follow a categorical structure mirroring that of the semantics.)
Let us set issues of intensionality aside momentarily, and assume that proper names receive semantic values of category $e$, and sentences semantic values of category $t$. As a prolegomena to the Big Puzzle, we first formulate a Little Puzzle:

**Little Puzzle:** Consider a simple subject-predicate sentence such as:

- Socrates snores.

and conclude that *snores* is of category $<e, t>$ (enabling it to combine functionally with *Socrates’s* $e$-value to produce a $t$-value for the whole sentence). But now consider a similar sentence with a quantified noun phrase as subject, such as:

- Some philosopher snores.

The puzzle: given that *snores* is $< e, t >$, how can we type *some philosopher*?

The Little Puzzle is rather familiar ground – we have two syntactically covarying classes of expressions with semantically very different functions. We could smooth over the semantic difference by assigning *some philosopher* a semantic value from category $e$. Lewis (1970) (p. 52) has shown both how to pursue this course and what the costs of that pursuit are; most prefer not to pay the price. Given a categorical semantic theory, only one other option exists – the semantic values of *some philosopher* and *snores* must combine functionally to produce a semantic value of
category $t$, and snores is of category $<e,t>$, so if some philosopher is not of category $e$, it must be of category $<<e,t>,t>$. We enable the intransitive verb to combine with both referential and quantificational subjects by having one such subject provide an argument to the verb and having the other such subject take the verb as an argument.

To assign a quantified noun phrase to $<<e,t>,t>$ is (because a function from a category to $t$ is a characteristic function on that category, and hence equivalent to a subset of that category) to give it a set of sets of individuals as semantic value. Treating quantifiers in this way as second-order properties is an idea found already in Frege (originally in Frege (1884) §53), and more recently pursued vigorously in the generalized quantifier literature springing from Barwise and Cooper (1980). Generalized quantifier theory gives us a very nice picture and answers the Little Puzzle, but it also lays the ground for the Big Puzzle:

**Big Puzzle**: Consider quantified noun phrases in direct object positions, as in:

- Socrates admires some philosopher.

Since some philosopher is of category $<<e,t>,t>$, admires must be of category $<<<e,t>,t>,<e,t>>$ (so that it can combine with some philosopher to produce a VP of category
<e,t> able to combine with the category-\(e\) Socrates). But now the earlier divide-and-conquer strategy can no longer succeed. If we have a sentence such as:

- Socrates admires Aristotle.

then the semantic analysis must crash. Admires is of category \(<<e,t>,e\),<e,t>>\) and Aristotle is of type \(e\), so neither can take the other as argument, and admires Aristotle cannot be semantically processed.

There are two major strands of response to the Big Puzzle in the formal semantics literature: those involving \textit{in situ} analyses, and those appealing to movement. \textit{In situ} analyses – which deploy tools stemming from Partee and Rooth (2002)’s treatment of generalized conjunction – compose the less familiar brand within philosophy – in such analyses, we supplement the semantics with \textit{type-shifting} operations which can move an expression from one type to another (higher) type. In simplest form, we then take transitive verbs such as admires to be of base category \(<e,<e,t>>\), but allow them to lift to category \(<<e,t>,e\),<e,t>>\). The lifted admires can then take as argument the \(<<e,t>,t>,<e,t>>\)-category \textit{some philosopher} to produce a verb phrase of (the typical) category \(<e,t>\). In the above example, that verb phrase then takes \(e\)-category Socrates as argument; in a case such as:

- Every linguist admires some philosopher.
the $<e,t>$ verb phrase serves as argument to the $<<e,t>,t>$-category quantified noun phrase. More generally, we start with the following type-shifting rule. Given any expression $\epsilon$ of any category $\alpha$, if we have available expressions of category $<\alpha,t>$, we can apply:

- **Lift**: The category $\alpha$ expression $\epsilon$ receives a lifted semantic value in category $<<\alpha,t>,t>$, where the particular semantic value is given by $\lambda x(\epsilon(x))$.

In the simplest case, Lift can move a referential $e$ expression to a generalized quantifier $<<e,t>,t>$ value, by assigning to it the set of all properties possessed by the original referent. In the transitive verb case, we simply lift the second argument position. The *in situ* analysis can be pursued in numerous ways – one could, for example, lift all $e$-category expressions, or further lift transitive verbs so that they take subject-position quantified noun phrases as arguments (hence, to $<<<<e,t>,t>,<<e,t>,t>,t>>$).

The morals to be drawn from *in situ* approaches, however, are common across these varied instantiations.

The second strand of response to the puzzle involves tools more familiar to philosophers. Rather than semantically processing quantified noun phrases *in situ*, we can appeal to movement rules which reorganize the sentence – for immediate purposes, the crucial effect is that the object-position noun phrase is re-
moved from its location as an argument of the transitive verb. Thus the sentence:

- \([s [NP \text{Every linguist}] [VP [TV \text{admires}] [NP \text{some philosopher}] ]]]\)

undergoes movement to form:

- \([s [NP \text{Every linguist}] [NP \text{some philosopher}] [x [\text{admires} y] ]]]\)

The goal here is for the first quantifier in order of processing – *some philosopher* – to take the matrix as input and produce some output, and then for that output to serve in turn as input to the second quantifier *every linguist*. But telling the story properly is difficult. Suppose we categorize *admires* in the simplest way, as \(<e, <e, t>>\). First we encounter a question regarding the semantic interaction between *admires* and the variables \(x\) and \(y\). (Here we see the first appearance of questions regarding the role of variables.) Consider two options:

1. Variables are of semantic category \(e\). Then *admires* \(y\) is of category \(<e, t>\) (with \(<e, <e, t>>\) taking \(e\) as argument), and *\(x\) admires* \(y\) is of category \(t\). But then semantic processing crashes – *some philosopher* is of category \(<<e, t>, t>,\) and cannot take \(t\) as argument (nor, of course, serve as argument to \(t\)).

2. Variables do not take semantic category, and are transparent to the semantic processing. Then *\(x\) admires* \(y\), like *admires*, is
of category \(<e, e, t>>\). But then semantic processing again crashes – some philosopher’s category \(<<e, t>, t>>\) can neither take \(<e, e, t>>\) as argument nor serve as argument to it.

These are only two among many options, of course, but their failure is a symptom of an underlying difficulty. Incompatible category demands are being placed here on the quantified noun phrases – given the use of movement to raise all quantified noun phrases to the top of the syntactic tree, we need each such quantifier to perform two tasks:

1. To take as input the output of a previous quantifier.

2. To produce as output a semantic value which can serve as the terminal semantic value of the sentence.

Note that the method utilized by the in situ approach of having one quantifier serve as argument and another as function cannot work here if we assume that quantifiers can be nested arbitrarily deep – at most two quantifiers can be accommodated by this role-swapping. If we assume that sentences receive semantic value \(t\), then quantifiers must, given these constraints be of category \(<t, t>\), but no semantic value in this category matches the logical demands imposed by quantifiers.

To put the problem in another way: suppose quantifiers take as semantic values properties of properties. Then in a multiply-quantified sentence, the innermost quantifier need to be predi-
cated of a property – but in being so predicated, a truth value results. The next second-order property in line then has nothing of the right type to be predicated of, and semantic processing must crash. Put in this way, the problem is a problem in the Fregean metaphysics of semantic values, and the problem then finds its solution in another aspect of that Fregean metaphysics (and a more recent formal implementation in Lewis (1970) and Cresswell (1973). We need an additional semantic operation of abstraction, in which (to put it in Fregean language) a saturated entity is subtracted from a truth value to (re)create an unsaturated property.

Formally, this abstraction process then provides a place for variables in the system. Following Lewis (1970), we work with syntactic forms enriched with some covert structure, such as:

- \[ s [NP \text{ Every linguist }] [vp [ \hat{x} ] ] [s [NP \text{ some philosopher }] [vp [ \hat{y} ] ] [s \times [vp [TV \text{ admires } y ] ] ] ] ] \]

The hat-labelled variables mark points of application of abstraction, in which a \( t \)-category semantic value is restored to an \( < e, t > \) value. Semantic processing thus proceeds in the following manner:

1. Category \( < e, < e, t > \) \textit{admires} combines with category \( e \ y \) to form an expression of category \( < e, t > \).
2. This category \(<e,t>\) expression then combines with category \(e\ x\) to form an expression of category \(t\).

3. This category \(t\) expression then, under application of \(\hat{y}\), undergoes abstraction to form an expression of category \(<e,t>\). The particular semantic value assigned from this category can be specified in the \(\lambda\)-calculus by:

   - \(\lambda y(x \text{ admires } y)\)

4. This \(<e,t>\) expression then serves as argument to the \(<<e, t>, t>\) quantified noun phrase \(\text{some philosopher}\) to produce an(other) expression of category \(t\).

5. That \(t\) category expression then undergoes abstraction via \(\hat{x}\) to produce another \(<e,t>\) value – this time:

   - \(\lambda x(x \text{ admires some philosopher})\)

6. Finally, the \(<<e, t>, t>\) quantified noun phrase \(\text{every linguist}\) takes that \(<e,t>\) expression as argument to produce the terminal \(t\) value.

We can at this point extract a first moral regarding the semantic role of variables:

**Moral 1**: It is often said that Frege’s introduction of the logic of relations makes possible his general treatment of nested quantification. But the current line of development suggests that this is misleading. A theory of relations alone is a theory
of multiply-unsaturated entities, and this category-theoretic picture by itself will allow – as seen above – only two levels of prenexed quantification (this claim is too quick, as we will see when we return to more sophisticated \textit{in situ} approaches below, but it is correct to a first approximation). With the theory of relations as one’s only tool, one must, in constructing a quantified sentence, enter the categorical hierarchy at some determinate point, and then descend with each application of quantification. The procedure is not genuinely recursive, and once the entry point is chosen, a finite cap on the number of available quantifications is inevitable. \textit{Unlimited} prenex quantification depends instead on the abstraction operation, which allows a procedure of \textit{re-initialization}, through which the categorical hierarchy can be \textit{ascended} as well as descended, allowing for genuine recursion. We thus find a distinctive semantic function for the variable – as the device of re-initialization, making a claim apt for quantificational specification.

One can assign the $\hat{x}$ and $\hat{y}$ variable abstractors a place in the semantic type hierarchy – the relevant category is $<t,<e,t>>$ – but attempting to detail the particular semantic value shows how artificial the resulting assignment is. Since category $t$ has only two elements (the true and the false), an element of category $<t,<e,t>>$ can produce only two output $<e,t>$ properties. Since we need an unlimited array of properties to give semantic
analysis to an unlimited array of matrix expressions, we then need an unlimited array of numerically and semantically distinct variable abstractors. Better, then, not to situate abstraction in the type hierarchy, and instead to recognize it as a genuine second mode of semantic formation. There is saturation – functional combination of typed semantic values – and there is abstraction. Hence a second moral:

**Moral 2:** The semantic intervention of variables on the Fregean model marks a fundamentally non-compositional moment in semantic processing – either directly, because the output unsaturated \(< e, t >\) property cannot be predicted on the basis of the input simple truth value (this is a manifestation of the Fregean thought that abstraction genuinely *creates* structure, rather than merely *revealing* pre-existing structure) or covertly, by requiring an in-principle infinite collection of atomic semantic devices.

Attempting to place variables-as-abstractors in the categorical hierarchy can draw attention to a peculiarity of the story thus far. Note that the expression \(x \text{ admires } y\) is meant to be of category \(t\), and hence to be assigned a truth value. But, of course, it is obscure what truth value that might be, because there is a second, non-abstractor, deployment of variables here – minimally, as mere syntactic placeholders requesting a semantic movement toward category \(t\) without providing a path for that movement (absent a genuine \(e\) value for the variables). However, the apparent
second role is deceptive – we can rebuild the picture (in a more faithfully Fregean manner) using names instead. We thus use an underlying structure such as:

- \[ \begin{array}{c}
  \text{NP Every linguist} \quad \text{VP} \quad \hat{x} \\
  \text{NP some philosopher} \quad \text{VP} \quad \hat{y} \\
  \text{NP John} \quad \text{VP TV admires} \quad \text{NP Mary}
\end{array} \]

in which uncontroversially \( e \)-category expressions produce a straightforward initial \( t \) value, which is then abstracted by the variables by way of Fregean subtraction of those entities.

So much for the two standard solutions to the opening puzzle. Note that one solution – the movement solution – gives us variables-as-abstractors, while the other (\textit{in situ}) solution makes no essential use of variables. But there is a steep price to be paid for avoiding the use of variables: the \textit{in situ} account as given cannot capture scope ambiguities. The \textit{in situ} account can give two categorical analyses to:

- Every linguist admires some philosopher

by taking admires to be \( <<<e, t>, t>, <e, t>> \) (in which case the verb phrase serves as argument to the subject quantified noun phrase) or to be \( <<<e, t>, t>, <<<e, t>, t>, t>> \) (in which case the verb phrase takes as argument the subject quantified noun phrase). But both categorical pictures produce a universal-existential reading, given the necessary assumption
that we assign to the quantified noun phrases the *particular* values:

1. $\llbracket \text{every linguist} \rrbracket = \{ X : \llbracket \text{linguist} \rrbracket \subseteq X \}$

2. $\llbracket \text{some philosopher} \rrbracket = \{ X : \llbracket \text{philosopher} \rrbracket \cap X \neq \emptyset \}$

However, the failure of the *in situ* approach to produce inverse (here, existential-universal) scope readings is due only to a failure of nerve in the type lifting. If we are sufficiently generous with the type-lifting mechanisms, we can in fact produce an *in situ* account which allows quantifiers to take arbitrary (logical) scope. The details are messy and incidental to the current discussion, but the basic idea comes out most clearly in the project of *continuation semantics* pursued in Barker (2002), Barker and Shan (2008) (similar ideas also appear in the Flexible Montague Grammar of Hendricks (1933) and the Dynamic Montague Grammar of Groenendijk and Stokhof (1989)). In continuation semantics, the semantic value of an expression is roughly a set of instructions for how it is to combine with (semantic values of) other expressions higher up in the syntactic tree. An expression can thus have a *deferred* semantic value, which is designed to have no impact until later in the tree, when it finally finds its desired partner (as a familiar and very simple example, consider non-intersective adjectives, which can be thought of as taking as semantic value instructions for interacting with a nominal’s semantic value). Given a sufficiently rich collection of type-
lifting principles designed to shift the degree of deferment of an expression, we can then control the order in which quantifiers achieve their semantic impact, and thereby produce arbitrary scopings. Thus we have:

**Moral 3:** Without the issue of quantifier scopings, the Big Puzzle would be, from the point of view of the *in situ* accounts, simply another version of the Little Puzzle (a simple question of how to type quantified noun phrases so as to account for their full syntactic range of occurrence). The Big Puzzle is thus more deeply a puzzle about *displaced semantic processing* – a puzzle about how we can ensure that quantified noun phrases can be processed in a way not obviously corresponding to their surface syntactic position. The two standard approaches thus amount to two forms of displaced semantic processing. The *in situ* approach is broadly semantic – displacement is achieved by using displaced semantic values that defer semantic integration. The movement+abstraction approach is broadly syntactic – displacement is achieved by relocating the expressions to be processed, placing them in various orderings. Thus the use of variables-as-abstractors is, more or less, the price of achieving displacement syntactically, since the syntactic approach requires a semantic mechanism of re-initialization.
In both cases, displaced semantic processing raises the spectrum of non-compositionality. Moral 2 already observes that the abstraction approach can be straightforwardly non-compositional, or it can reject a finiteness constraint that compositionality is intended as a means of enforcing. The kinds of deferment techniques used by in situ approaches have been known since Janssen (1997) and the literature following Zadrozny (1994) to be methods of reworking any semantic theory into a compositional form, and thereby robbing compositionality of its bite as a semantic tool.

I claimed at the outset that this type-theoretic puzzle about quantification was relatively unfamiliar to philosophers, despite being common coin among formal semanticists. Philosophers typically fail to see this puzzle for a good reason: their received semantic picture is one on which the puzzle simply fails to arise. The philosophically received picture is the Tarskian semantics, on which quantification proceeds by manipulation of a satisfaction relation between sentences and sequences. This picture can, for current purposes, be usefully recast in categorical terms. Suppose we have a (perhaps uncountable) collection of countably infinite sequences (thought of as functions from N to some privileged domain of objects). Then we can build a new type hierarchy on a broadened base of sequence-relativized semantic values. Category $t'$ consists of sets of relativized truth values of the form:
• true-relative-to-sequence-$\sigma_1$

• false-relative-to-sequence-$\sigma_2$

For simplicity, we can then take the elements of $t'$ to be sets of sequences (those, e.g., relative to which the expression is true). Category $e'$ consists of sets of relativized referents, such as:

• object-$o_1$-relative-to-sequence-$\sigma_1$

• object-$o_2$-relative-to-sequence-$\sigma_2$

Again for simplicity, we take the elements of $e'$ to be sets of ordered pairs of objects and sequences. The rather artificial use of sets of values in categories $t'$ and $e'$ is a reflex of the relational, rather than functional, nature of the semantics.

Proper names are $e'$ expressions, taking as semantic values maximal sets projecting (along the relevant dimension) to a single object:

• $\llbracket \text{Socrates} \rrbracket = \{ <o,\sigma >: o = \text{Socrates} \}$

Variables are also $e'$ expressions, but take as semantic values projections involving coordination with a particular position in a sequence. Hence:

• $\llbracket x_1 \rrbracket = \{ <o,\sigma >: o = \sigma(1) \}$

and more generally, variables are those elements $X \in e'$ meeting the constraint:
• \( \exists n \forall < o, \sigma > \in X \sigma(n) = o \)

Admires is of category \(< e', < e', t' >> \) – or, to simplify harmlessly, a function from a pair of \( e' \) values to a \( t' \) value – and takes as semantic value a function \( f \) such that, given any \( X = \{ < o_i, \sigma_i > \} \) and \( Y = \{ < o_j, \sigma_j > \} \), we have:

• \( f(X, Y) = \{ \sigma : \exists o_1, o_2(< o_1, \sigma > \in X \land < o_2, \sigma > \in Y \land o_2 \text{ admires } o_1) \} \)

A bit of calculation then shows that:

• \( \llbracket x_1 \text{ admires } x_2 \rrbracket = \{ \sigma : \sigma(1) \text{ admires } \sigma(2) \} \)

Quantified noun phrases can now take category \(< t', t' >\). This was a potential way out earlier, but was blocked because \( t' \) – then a simple truth value – was not a suitable semantic argument for a quantified noun phrase. But with the more richly articulated base class \( t' \), the correct clauses can be written down straightforwardly:

• \( \llbracket \text{some philosopher} \rrbracket_j = f \text{ such that } f(X) = \{ \sigma : \exists o(o \text{ is a philosopher } \land \exists \sigma'(\sigma'(j) = o \land \forall n \neq j \sigma(n) = \sigma'(n) \land \sigma' \in X) \} \}

• \( \llbracket \text{every linguist} \rrbracket_j = f \text{ such that } f(X) = \{ \sigma : \forall o(o \text{ is a philosopher } \rightarrow \exists \sigma'(\sigma'(j) = o \land \forall n \neq j \sigma(n) = \sigma'(n) \land \sigma' \in X) \} \}

Every linguist admires some philosopher then, given a movement-based syntax, composes straightforwardly and produces a terminal semantic value which is either the set of all sequences orpol
the set of none.

A clean semantic story, easily placed in a categorical structure, is thus familiar to philosophers. This semantic story does not use variables as devices of abstraction, but rather as devices of (sequence-relativized) reference. Hence another moral:

**Moral 4:** Variables can be thought of in either of two opposed ways. We can treat variables as devices of abstraction, and preserve simple truth at the base of the semantic type hierarchy. The variables then serve to re-initialize, so that we can climb a syntactic tree without danger of losing connection with the hierarchical base. Or we can treat variables as devices of reference, and replace simple truth with a notion of relativized truth which allows us to continue information processing once the hierarchy has bottomed out.

The Tarskian semantics, like the Fregean one, is formally impeccable. The question then is whether it is conceptually satisfactory. In the Fregean case, the conceptual price was the distancing from clean compositionality. The Tarskian semantics is clearly compositional – the question now is whether the fundamental semantic coin of truth relative to a sequence can integrate with a plausible pragmatics. A semantic theory cannot be a free-floating entity – it must integrate with broader concerns regarding the conditions under which people perform and receive speech acts, and the informational, cognitive, behavioural, and worldly changes they
bring about through their linguistic activities. So, for example, suppose that an utterance \( u \) has been made, and a recipient of this utterance is considering what alteration in his cognitive state is warranted by \( u \). The question of the truth value of \( u \) then becomes relevant – if he has reason to think that \( u \) is true, he should react in one way (roughly, adding \( \text{that } u \) to his stock of beliefs), but if he has reason to think that \( u \) is false, he should react in a different way.

But what if he thinks that \( u \) is true relative to sequence \( \sigma_1 \), and false relative to sequence \( \sigma_2 \)? How do these relativized semantic values integrate with practical concerns regarding what to do with an utterance? Two aspects of the pragmatic integration worry can be isolated:

1. **Predictive**: One might hope that the familiar fact that closed sentences are satisfied either by all sequences or by none would obviate the worry, since the pragmatics could run off of the two semantic features satisfied by all sequences (‘true’) and satisfied by no sequences (‘false’). But if we ever need to accommodate open sentences with the pragmatics, this approach will fail. And plausibly many natural language sentences, such as those containing deictic pronouns, are open.
2. **Conceptual:** It is generally regarded as desirable that we have some conceptual grip on the properties which undergird our semantic theories, even if those properties do not manifest at the terminal level. Thus, for example, we want an understanding of what *truth at a world* might be, before we build a modal semantics on it.

The general shape of the worry here is a familiar one, which has been confronted by a number of relativized truth, or *truth at an index*, theories. Theories of indexicality lean on an intuitive and pragmatically fruitful notion of truth at a context of utterance; Kamp (1970)’s double-indexed semantic theory relies on a reduction, via truth along the diagonal, of double-indexed truth to truth at a context of utterance (and arguably Kaplan (1989)’s major advance over Kamp’s formal picture is a richer conceptual grounding of the diagonalizing strategy on a semantic separation of the two indices into character and content); and the fate of recent work in truth relativism presumably rides on the viability in a broader pragmatics of a notion of truth at a point of assessment.

The familiar worry arguably has a familiar solution. Consider a Kaplanian picture of contexts as ordered tuples of objects. Among these objects we need objects to serve as potential referents of demonstratives and deictic pronouns – a natural model here is that context provides us with a salience-ranked sequence
of objects, and the language is thought of as supplied with a collection of demonstratives and deictic pronouns aimed at different salience positions (but all sharing the same surface form).

So:

- \( \text{He}_1 \) admires \( \text{him}_2 \).

requires (more or less) that the most salient object in the context admires the second-most salient object. This picture then extends in a natural way to a treatment of variables in the Tarskian manner:

1. Variables are individuated by the position in the salience ranking from which they inherit referents.

2. Truth relative to a sequence is equated with truth in a context providing that sequence as its salience ranking.

Hence, a final moral:

**Moral 5:** The two-way competition between variables-as-abstractors and variables-as-referrers is deceptive – it hides a deeper (at least) three way competition between mechanisms for achieving displaced semantic processing:

1. Displacement can be achieved semantically, as in *in situ* approaches which leave expressions in their syntactic position but type-shift them so as to achieve semantic processing in the desired order.
2. Displacement can be achieved syntactically, as in movement+abstraction accounts in which expressions are syntactically relocated and then processed through a simpler type hierarchy in their syntactic order of occurrence.

3. Displacement can be achieved metasemantically, as in the Tarskian account which uses (along with movement) a semantic coin which allows deferred information to be passed on (as it were) horizontally rather than (as in type-shifting accounts) vertically.

Variables are a tool for displacing semantic processing, but the question of deeper interest is the status of the displacement, and the threat it raises to compositionality.

Now consider two worries about the ability of the Tarskian account to achieve the needed integration of semantics and pragmatics:

1. Quantifiers now become Kaplanian monsters, since they shift the sequence under consideration, and thereby shift the context. But that an operator is a monster is an objection only to the extent that monsters are objectionable, and monsters are taken to be objectionable by Kaplan only because natural language appears not to contain them. But natural language clearly does contain quantifiers, so if they are monsters, the objection to monsters is thereby defeated.
2. The standard Tarskian semantics employs infinite sequences, but clearly no realistic pragmatics will support a notion of context supplying an infinite salience ranking of objects. This is a more substantial worry, but there is an available line of response that leads to a final moral.

Tarskian semantics employs infinitely many sequences in order to make the recursive mechanisms run smoothly – since, at any point in semantic evaluation, we do not know what additional variables may appear at later (larger) stages, we carry along potential values for those variables in (currently idling) sequence positions. But this is not the only formal option – we could just as well have a notion of a dynamically-extendible sequence. Semantic processing could then start with an empty sequence (or perhaps with a small finite sequence reflecting contextually-available salience facts), and when, in the recursive mechanisms, a variable is encountered requesting a salience position not given in the sequence, a new and expanded sequence would come into consideration – expanded to contain a value for the relevant salience position.

It is possible to give such a semantics in the standard Tarskian framework – the result is more or less the game-theoretic semantics advocated by Hintikka (1973), restricted to games of perfect information. But another perhaps more perspic-
uous, and more conceptually enlightening, approach takes seriously in the semantics the idea of dynamic extendibility of the sequence. The core dynamic idea follows that set out in the Dynamic Predicate Logic of Groenendijk and Stokhof (1991) – sentences are given as semantic values maps from incoming sequences to outgoing sequences. But we add to this basic framework the thought – pursued in Dekker (1994) – that this mapping acts on finite sequences and can extend those sequences. The core semantic clauses are those for atomics and quantifiers:

a) Given atomic $Rx_{i_1} \ldots x_{i_n}$ and (finite) sequence $\sigma$, $[\sigma] \uparrow$ 
   $Rx_{i_1} \ldots x_{i_n} = \{ \sigma' : \forall n(\sigma(n) \text{ is defined} \rightarrow (\sigma'(n) \text{ is defined} \land \sigma'(n) = \sigma(n))) \land \forall n((\sigma(n) \text{ is not defined} \land \sigma'(n) \text{ is defined}) \rightarrow (n = i_1 \lor \ldots \lor n = i_m) \land <\sigma'(i_1),\ldots,\sigma'(i_n)> \in \llbracket R \rrbracket) \}$

b) Given quantifier $\exists x_i$ and (finite) sequence $\sigma$, $[\sigma] \uparrow \exists x_i =$ 
   $\{ \sigma' : \forall n(\sigma(n) \text{ is definite} \rightarrow (\sigma'(n) \text{ is defined} \land (n \neq i \rightarrow \sigma(n) = \sigma'(n))) \land \forall n((\sigma(n) \text{ is not defined} \land \sigma'(n) \text{ is defined}) \rightarrow n = i) \}$

And so, a final plug and some rumination to accompany the morals:

**Weighing the Costs**: A central theme of these considerations has been that we are going to need some form of displaced semantic processing. Three modes have been examined here – a broadly semantic displacement via variable-
free in situ type shifting, a broadly syntactic displacement via movement (enabled by variables-as-abstractors), and a broadly metasemantic displacement via a basic semantic coin which can carry deferred processing information from one stage to the next, and which utilizes variables-as-referrers as hooks for accessing the deferred information. Doubtless other modes are conceivable. But in any manifestation, displaced semantic processing represents a threat to compositionality broadly understood (if not narrowly defined). Threats to compositionality are typically taken as a sign that a semantic device is too powerful, but some work needs to be done to uncover what lies behind this complaint.

A device’s power is a measure of how wide a range of phenomena it can model, so on the face of it a complaint that a semantic device is too powerful is an odd one, since it seems only to guarantee that natural language can be modelled. But as the power of one device increases, the constraints that need to be placed elsewhere decrease (thus, for example, free shifting to oblique referents in opaque contexts decreases the constraints on singular term reference) – and if we value those constraints, we may object to the increased power. My own preferred constraint of value is that which a semantic theory places on lexical semantic values, which may in turn reflect ontological and ideological commitments of philosophical interest, but this is not the place to pursue in detail.
the particular costs paid for losing (broad) compositionality. If we simply accept that there are costs, we need to keep displaced semantic processing in check.

One method of checking is syntactic. Here we may find reasons to prefer variable-based approaches to variable-free ones, since both variable-based approaches make crucial use of syntactic movement to achieve the full range of displacement (including inverse-scope readings). The in situ accounts are not syntactically beholden, since the type raising can achieve inverse-scope readings without regard to where the quantifiers are placed, but the variable-based approaches need to get the quantifiers in the right order. Thus syntactic theory can serve as a check on displacement – we can eliminate some theoretically possible displacements on the grounds that the syntax does not allow the needed movement. So, for example, we block (syntactically) inverse scope readings involving quantified noun phrases in movement islands, as in:

- Every linguist who admires some philosopher is happy.

which has only the universal-existential reading. But the issues rapidly become complicated here. Scoping availability is only imperfectly linked to movement permissibility, as the generally free scoping of indefinites shows (see Reinhart
(1997) for detailed discussion of the issues here). Further epicycles on semantic displacement, such as Discourse Representation Theory’s treatment of indefinites as a form of content-enriched variable, become relevant at this point (see paradigmatically Kamp (1981)).

A second method is more broadly conceptual. We can ask which displacement mechanism – syntactic, semantic, or metasemantic – integrates best with larger concerns regarding the shape of semantic theorizing. I have tried to suggest briefly that the metasemantic approach, when wedded to a dynamic perspective on meaning, is arguably preferable on these grounds. (The Fregean variables-as-abstractors approach is also, I think, a plausible candidate – much here will depend on the ultimate coherence of the idea of subtraction as a tool for creating, rather than merely revealing, structure. This idea, in turn, likely stands or falls with the entire neo-Fregean ontological project.) But again, many complicated issues emerge at this point. Some of the conceptual success of the metasemantics+dynamics approach lies in its treatment of unbound pronouns, but the question of whether unbound pronouns are best thought of as forms of variables is itself a complicated one, resolution of which is likely to involve discussion of donkey anaphora, modal subordination, paycheck pronouns, and i-within-i effects. Obviously this is not
the place to attempt the needed resolution – the concluding hortative is merely that this is the way forward, and the issues that need to be discussed to gain further clarity on the status of variables.

References


