On the paths to alternatives

Computational semantics seminar

January 25, 2017

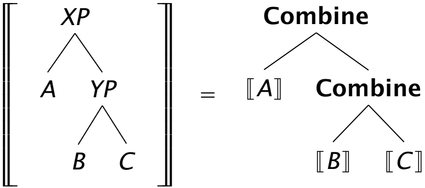
A bit of review

Basic composition

Define a recursive interpretation function $[\![\cdot]\!]$, as follows:

$$[\![[_{XP}\ \Gamma\ \Delta]]\!] := \textbf{Combine}\,([\![\Gamma]\!], [\![\Delta]\!])$$

Then, the interpretation for *XP* is calculated as follows:



Enriched composition regimes #1

Assignment-sensitivity: extracting values at assignments.

$$\textbf{Combine}^{+}(l, r) := \lambda g.\textbf{Combine}(l\,g, r\,g)$$

Alternatives: point-wise composition.

$$\textbf{Combine}^{+}(l, r) := \{\textbf{Combine}(l', r') \mid l' \in l, r' \in r\}$$

Enriched composition regimes #2

Supplemental content: keeping track of some secondary content.

$$\mathbf{Combine}^{+}((l, p), (r, q)) := (\mathbf{Combine}(l, r), p \wedge q)$$

Focus: doing regular and point-wise composition in parallel.

$$\mathbf{Combine}^{+}((l, S), (r, T)) := (\mathbf{Combine}(l, r), \{\mathbf{Combine}(s, t) \mid s \in S, t \in T\})$$

[If you had a look at the coding exercises from last week, these semantic clauses should remind you of something: namely, *pattern matching*.]

Abstraction #1

Each instance of **Combine**$^{+}$ represents a *proper enrichment* of **Combine**, in the sense that **Combine**$^{+}$ is defined *in terms of* **Combine**.

So we're extending bare-bones combination with assignment management, the ability to deal with multiple values in tandem, the ability to accumulate supplemental content, and the ability to do regular and point-wise composition in parallel.

Abstraction #2

Moreover, many boring things don't exist essentially in the higher space. So there is in general a systematic way to relate boring values with maximally boring fancy values. Let's call this function η.

Let's review how η is defined for each case:

$\eta\, x := \lambda g.\, x$	*Assignments*
$\eta\, x := \{x\}$	*Alternatives*
$\eta\, x := (x, \mathbb{T})$	*Supplements*
$\eta\, x := (x, \{x\})$	*Focus*

Our job in this seminar

Considering various enrichments

Observing a common abstract structure

Seeing if we can factor that structure out

Investigating empirical consequences thereof

A thought experiment

Let’s suppose that our grammar is defined in terms of some enriched **Combine**$^+$ operation (pick your favorite one to think about).

But now, somewhat perversely, let’s imagine that *everything in the language* has a value of the form $\eta\, x$, for some x. In other words, nothing really uses the additional fanciness given to us by **Combine**$^+$.

Would you say that such a grammar was *equivalent* to the grammar with just **Combine**, and where every $\eta\, x$ was just replaced with x?

Continuing the thought experiment

It seems to me like the enriched grammar (with **Combine**$^{+}$) wasn't really an enrichment at all.

We've just given a trivial *injection* of the boring grammar into an enriched one. Why, then, did we bother?

In other words, enriched modes of composition really require some things that live *essentially* in the richer type-space targeted by **Combine**$^{+}$.

Another thought experiment

We will make some hay about combining different enrichments. But it may look to you as if this, too, is a somewhat trivial matter:

$$\textbf{Combine}^{+g\rightarrow}\,(l, r) := \lambda g.\textbf{Combine}^{+?}\,(l\,g, r\,g)$$

What happens, for example, if we wrap this operation around $\textbf{Combine}^{+\{\}}$? Can you work out what that amounts to?

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What happens, for example, if we wrap this operation around $\mathbf{Combine}^{+\{\}}$? Can you work out what that amounts to?

$$\lambda g.\mathbf{Combine}^{+\{\}}(l\,g, r\,g) = \lambda g.\{\mathbf{Combine}\,l'\,r' \mid l' \in l\,g,\ r' \in r\,g\}$$

Continued...

Repeating the super-enriched combination operation:

$$\lambda g. \{\textbf{Combine}\, l'\, r' \mid l' \in l\, g, r' \in r\, g\}$$

And what is the correponding η operation?

Continued...

Repeating the super-enriched combination operation:

$$\lambda g. \{\mathbf{Combine}\, l'\, r' \mid l' \in l\, g, r' \in r\, g\}$$

And what is the correponding η operation?

$$\eta\, x := \lambda g. \{x\}$$

Can you think of another way to express this?

Continued...

Repeating the super-enriched combination operation:

$$\lambda g.\,\{\mathbf{Combine}\, l'\, r' \mid l' \in l\, g,\, r' \in r\, g\}$$

And what is the correponding η operation?

$$\eta\, x := \lambda g.\,\{x\}$$

Can you think of another way to express this?

$$\lambda x.\, \eta_{g\rightarrow}(\eta_{\{\}}\, x)$$

[This is also known as the **composition** of $\eta_{g\rightarrow}$ and $\eta_{\{\}}$.]

And a final thought experiment

Does the following seem perverse?

$$\textbf{Combine}^{+}(l, r) := \textbf{Combine}(l, r)$$

It seems kind of silly, right, imagining an “enriched” mode of composition that boils down to the basic one we already had? Well, maybe! Bearing with me, though, what would the η function be here?

And a final thought experiment

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It seems kind of silly, right, imagining an “enriched” mode of composition that boils down to the basic one we already had? Well, maybe! Bearing with me, though, what would the η function be here?

$$\eta\, x = x$$

(That’s the identity function!)

Continued…

Recall our "wrapping" schema for assignment-sensitivity:

$$\textbf{Combine}^{+g\to}\,(l, r) := \lambda g.\textbf{Combine}^{+?}\,(l\,g, r\,g)$$

How does this interact with our trivially enriched mode of composition?
How do the two η operations compose?

Predicative indefinites and the Partee $\triangle$

Predicative uses of indefinites

One of the basic uses of indefinites is in predicative position:

1. I'm a linguist.
2. Mary considers John a linguist.

Two possibilities for the basic meaning of indefinites — on the left, as a set of individuals (i.e., a predicate); on the right, as a GQ:

$$[\![\text{a linguist}]\!] = \{x \mid \textbf{ling}\, x\} \qquad [\![\text{a linguist}]\!] = \lambda f.\exists x \in \textbf{ling} : f\, x$$

$$\text{type: } \mathsf{S}\,\mathsf{e} \qquad \text{type: } (\mathsf{e} \to \mathsf{t}) \to \mathsf{t}$$

No matter which you choose, you need a mapping from one to the other!

The predicative use as basic

Let's suppose for concreteness that the predicative use of indefinites is basic (nothing much turns on this). What's the mapping into GQs?

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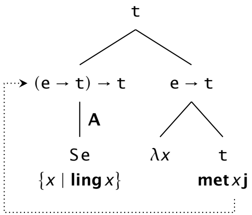
$$\mathbf{A}\, m \coloneqq \lambda f.\, \exists x \in m : f\, x$$

[If treating the GQ use as basic, the relevant mapping is $\mathbf{BE}\, Q \coloneqq \{x \mid \{x\} \in Q\}$.]

A basic derivation

Here, we derive *John met a linguist*:



The result, as expected: $\exists x \in \mathbf{ling} : \mathbf{met}\, x\, \mathbf{j}$.

[Can you figure out a treatment of the predicative cases?]

An observation

There is an interesting interaction between **A** and the η operation for alternative sets (i.e., such that $\eta\, x = \{x\}$).

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$$\begin{aligned}\mathbf{A}\,(\eta\, x) &= \lambda f.\, \exists y \in \{x\} : f\, y \\ &= \lambda f.\, f\, x\end{aligned}$$

Do you recognize this?

An observation

There is an interesting interaction between **A** and the η operation for alternative sets (i.e., such that $\eta\, x = \{x\}$).

$$\begin{aligned} \mathbf{A}\,(\eta\, x) &= \lambda f.\, \exists y \in \{x\} : f\, y \\ &= \lambda f.\, f\, x \end{aligned}$$

Do you recognize this? Sure, it's just Partee's (1986) **LIFT** operation, applied to x! In other words, **A** and η amount to a *decomposition* of **LIFT**!

$$\mathbf{A} \circ \eta = \mathbf{LIFT}$$

$[f \circ g := \lambda x.\, f\,(g\, x)]$

Partee (1986) triangle

This can all be summed up with the famous Partee triangle:

$$\begin{tikzcd}
(a \to \mathtt{t}) \to \mathtt{t} & & a \arrow[ll, "\mathbf{LIFT}_t"'] \arrow[d, "\eta"] \\
& & \mathsf{S}\, a \arrow[ull, "\mathbf{A}"]
\end{tikzcd}$$

This diagram **commutes**: where there exist multiple paths between two nodes, those paths are *equivalent* (which just amounts to $\mathbf{A} \circ \eta = \mathbf{LIFT}$).

Alternatives in semantics

For questions

A very standard, very powerful idea about questions: the meaning of a question is **the set of its possible answers**.

$$[\![\text{who does John like?}]\!] = \{\mathbf{like}\, x\, \mathbf{j} \mid x \in \mathbf{human}\}$$

Dates back to Hamblin (1973) and Karttunen (1977), who had some differences, minor and major.

For indefinites

It's easy to imagine, as Ramchand (1997), Kratzer & Shimoyama (2002) do, that indefinites (or indefinite-like things, e.g., indeterminate pronouns) also trigger sets of alternatives:

$$[\![\text{John likes somebody}]\!] = \{\mathbf{like}\, x\, \mathbf{j} \mid x \in \mathbf{human}\}$$

We explored this idea a bit last time, and we'll pick it up again today.

For disjunction

It's also popular to treat disjunctions as introducting alternatives: 1. John might be in Paris or London.

This sentence seems to mean John might be in Paris, and John might be in London. Here's a standard analysis in terms of disjunction alternatives, following Simons (2005), Aloni (2007):

$$
\begin{aligned}
[\![X \text{ or } Y]\!] &:= [\![X]\!] \cup [\![Y]\!] \\
[\![\text{might } \phi]\!] &:= \forall p \in [\![\phi]\!] : \Diamond p
\end{aligned}
$$

For focus

Mary only introduced BILL to Sue:

$$\mathbf{intro}\,\mathbf{b}\,\mathbf{s}\,\mathbf{m} \wedge \forall x \in \mathbf{Alts_b} : \mathbf{intro}\,x\,\mathbf{s}\,\mathbf{m} \Rightarrow x = \mathbf{b}$$

A semantic clause for *only*:

$$\mathbf{only}\,(p, S) := p \wedge \forall s \in S : s \Rightarrow s = p$$

Of course, this isn't alternative semantics *per se*, since we also need the *ordinary value*. So this is really the enriched focus semantics. Still, alternatives play a central role.

How do they arise?

So alternatives are useful. But there's, of course, a compositional question: how to get them.

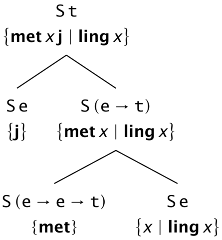
You might think it's silly to pose this. Don't we already have a **Combine**$^+$ that works nicely with alternative sets?

Indeed, we do (well, so far as we have seen). But as we saw a taste of last time, this leaves many questions open (and, moreover, there are competitors to the alternative-semantic line, e.g. Karttunen 1977). Let's review these points briefly.

Alternative semantics

Reminder

Like the semantics we just reviewed, alternative semantics takes the predicative use of indefinites as “basic”. But instead of positing an **A** shifter, composition is upgraded to **Combine**$^+$.



This can be turned into a garden variety existentially quantified proposition via a closure operation (can you define it?). So we arrive at the same result as before.

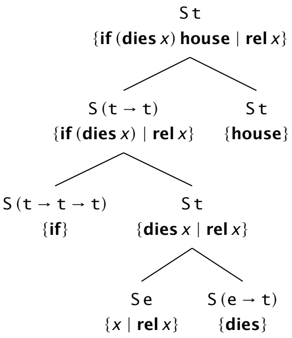
Reminder: indefinites on islands

Indefinites have a characteristic ability to project their scope out of domains that other operators cannot (Fodor & Sag 1982, Reinhart 1997):

- If [a rich relative of mine dies], I'll inherit a house. $\exists \gg \textit{if}$
- Each student has to come up with three arguments showing that [some condition proposed by Chomsky is wrong]. $\forall \gg \exists \gg 3$

True quantifiers (universals, negative existentials, etc.) in parallel positions are trapped inside the bracketed constituent.

Reminder: island-escape in alternative semantics



Point-wise composition allows in situ indefinites to pop their heads out of islands. This is an important motivation for alternative semantics.

Reminder: selectivity

Two indefinites on an island have the ability to take exceptional scope in different ways outside the island.

- If [a renowned expert on tax law visits a rich relative of mine], I'll inherit a house. $^{\checkmark}\exists_{lawyer} \gg \textit{if} \gg \exists_{relative}$, $^{\checkmark}\exists_{relative} \gg \textit{if} \gg \exists_{lawyer}$

Is this predicted by alternative semantics?

Reminder: selectivity

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- If [a renowned expert on tax law visits a rich relative of mine], I'll inherit a house. $^{\checkmark}\exists_{lawyer} \gg if \gg \exists_{relative}$, $^{\checkmark}\exists_{relative} \gg if \gg \exists_{lawyer}$

Is this predicted by alternative semantics? **NO!!** The grammar *insists* on returning a set of propositions as a meaning for the island.

$$\{\textbf{visits}\, y\, x \mid \textbf{expert}\, x, \textbf{rel}\, y\}$$

So alternative semantics is **unselective** in its bones.

Reminder: binding

Indefinites can be bound into and out of:

- No candidate$_i$ submitted a paper he$_i$ had written.
- A candidate$_i$ submitted her$_i$ best paper.

So there's a question about how to combine binding with alternatives. As we'll see next week, such combination is far from trivial!

Karttunen semantics redux

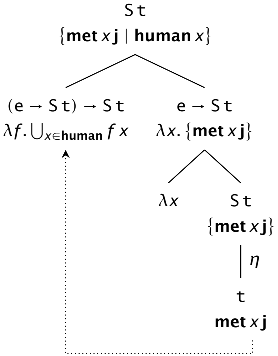
Another approach to alternatives: Karttunen (1977)

Instead of treating wh-words and indefinites as sets of alternatives and then upgrading composition to accommodate them, invoke some compositional magic:

$$\begin{aligned} \eta\, p &:= \{p\} \\ \textbf{who} &:= \lambda f.\, \textstyle\bigcup_{x \in \textbf{human}} f\, x \end{aligned}$$

A basic Karttunen-esque derivation

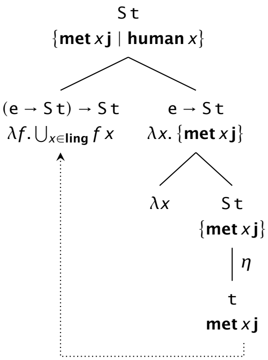
Here, we derive a meaning for *John met who?*



Notice that, just as in the case of quantification, *scope-taking* is a crucial part of the story.

Extending to indefinites (Heim 2014)

Here, we derive a meaning for *John met a linguist.*



The story is exactly the same. Notice, however, that we don't want to commit ourselves to thinking of declarative sentences with indefinites and questions as *precisely* the same sort of object.

Question: how does this all relate?

Our entries for indefinites (and wh-words) have a curious type:

$$(\mathsf{e} \to \mathtt{S}\,\mathtt{t}) \to \mathtt{S}\,\mathtt{t}$$

Perhaps the question is not so pressing why wh-words should have this type. But with indefinites, what's the relationship between their Karttunen guise and their other guises?

A modular vignette

Cresti (1995: 96), fn17 mentions an interesting possibility:

> [17] To be more explicit, we can imagine a *wh*-phrase as composed of an indefinite and a [+WH] component. So for instance, the meaning of *who* would be "some person x has property $\mathbf{P}$" with [+WH] applied to it. In other words: '$\lambda\mathbf{P}\exists x[\mathbf{person}(x) \wedge \mathbf{P}(x)]$', and '[+WH] $\rightsquigarrow \lambda\mathbf{U}\lambda\mathbf{W}\lambda p[\mathbf{U}(\lambda u.\mathbf{W}(u)(p))]$'. So [+WH] applied to "some person . . ." is '$\lambda\mathbf{U}\lambda\mathbf{W}\lambda p[\mathbf{U}(\lambda u.\mathbf{W}(u)(p))]\ (\lambda\mathbf{P}\exists x[\mathbf{person}(x) \wedge \mathbf{P}(x)])$' = '$\lambda\mathbf{W}\lambda p\exists x[\mathbf{person}(x) \wedge \mathbf{W}(x)\ (p)]$', as in (39).

In more familiar set-theoretic terms:

$$+wh :: ((\mathtt{e} \to \mathtt{t}) \to \mathtt{t}) \to (\mathtt{e} \to \mathtt{St}) \to \mathtt{St}$$
$$+wh := \lambda Q.\lambda f.\{y \mid Q(\lambda x.\, y \in f\, x)\}$$

[In fact, this mapping from GQs into things that can scope over sets was already in Karttunen, but as a composition rule.]

Adding to the Partee (1986) triangle

$$
\begin{tikzcd}
(a \to \mathtt{t}) \to \mathtt{t} \arrow[rr, bend left, "+\mathrm{wh}"] & a \arrow[l, "\mathbf{LIFT}_t"'] \arrow[d, "\eta"] & (a \to \mathtt{S}\,b) \to \mathtt{S}\,b \\
& \mathtt{S}\,a \arrow[ul, "A"] &
\end{tikzcd}
$$

[The diagram still commutes! Exercise: verify this.]

Hybrid approaches: Sternefeld (2001), Cable (2010)

Another possibility, explored by Sternefeld and Cable, is to turn a set of individuals back into an individual, via a *choice function*, which is then bound higher up:

$$[\![\mathrm{Op}_i\ X]\!] := \{[\![X]\!]^{i \to f} \mid f \in \mathbf{CH}\}$$

So the structure of an indefinite/wh-word looks like this:

[[a linguist] x_i]

This solves the compositional problem by reifying a set of individuals, back into a plain old individual, then varying that individual indirectly, via the higher Op_i.

Another approach

Starting with sets

Let's assume, again, that indefinites (and, if you like, wh) are in their bones sets. Let's take the predicative use as basic.

Sounds nice, but we need to solving the composition problem.

Possibilities surveyed so far:

- Partee's **A** shifter
- Alternative semantics
- Karttunen (with a +wh)

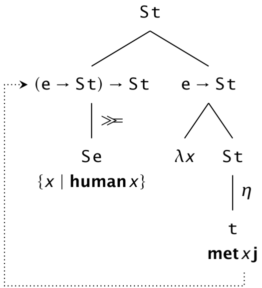
Another way?

Is there another way? Have we canvassed all the options?

Well, duh! There's something we haven't yet tried. Let's stick with Karttunen, and see if we can find an operation that allows us to map *sets* into the Karttunen-esque meanings for wh-words (and indefinite).

Solving for $\gg=$

Schematically, that would look like this:



We'd have a mapping from sets straight into meanings that scope over sets of alternatives. Can you reconstruct what that might be?

Solved

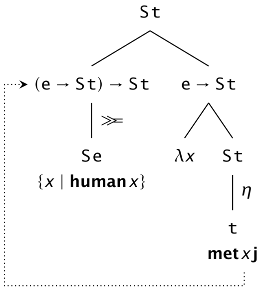
Here's the answer:

$$\eta :: \mathtt{t} \to \mathtt{S\,t} \qquad\qquad \ggg\!= :: \mathtt{S\,e} \to (\mathtt{e} \to \mathtt{S\,t}) \to \mathtt{S\,t}$$
$$\eta = \lambda p.\, \{p\} \qquad\qquad \ggg\!= = \lambda m.\, \lambda f.\, \bigcup_{x \in m} f\, x$$

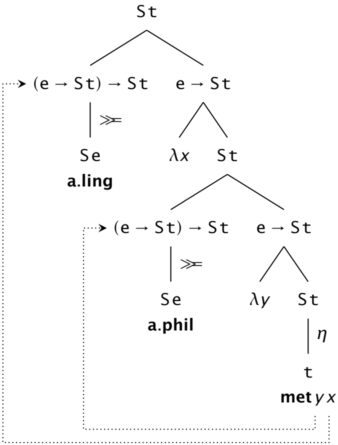
[Notice that Cresti's +wh analysis actually allows us to generate strange denotations for quantifiers like *nobody*. This is a (weak) argument that shifting sets rather than GQs might be preferable.]

Basic derivation

As expected, this yields $\{\mathbf{met}\,x\,\mathbf{j} \mid x \in \mathbf{human}\}$ for the following:



Derivation with two indefs



$$= \{\textbf{met}\, y\, x \mid x \in \textbf{ling},\ y \in \textbf{phil}\}$$

On hybrid approaches

Notice that this way of doing things has some things in common with the hybrid approaches of Sternefeld and Cable.

Like them, we treat sets as basic and provide some other glue to allow sets to compositionally get integrated, in the ultimate service of deriving new sets.

There are some important differences as well. Can you think of any?

Some general properties

Getting polymorphic

Does it make sense to restrict the types of these operations? Doesn't that seem ad hoc? Why not make them as general as possible (make the theory as strong as possible).

$$\eta :: a \to \mathsf{S}\,a \qquad\qquad \ggg\!= :: \mathsf{S}\,a \to (a \to \mathsf{S}\,b) \to \mathsf{S}\,b$$
$$\eta = \lambda x.\,\{x\} \qquad\qquad \ggg\!= = \lambda m.\lambda f.\bigcup_{x \in m} f\,x$$

Opening up new paths

This opens up some interesting new possible directions:

- Any set of alternatives, of any type, can take scope via $\ggcurly$.
- A set of alternatives can scope over anything, so long as that's a set.

So $\ggcurly$ isn't terribly picky about its left or right argument, beyond the fact that they're sets and functions into sets.

The interaction of η and $\gg=$

What do you notice about the following:

$$(\eta\, x)^{\gg=}$$

The interaction of η and $\gg\!=$

What do you notice about the following:

$$(\eta\, x)^{\gg=} = \lambda f.\bigcup_{y \in \{x\}} f\, y$$

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What do you notice about the following:

$$\begin{aligned}(\eta\, x)^{\gg=} &= \lambda f.\bigcup_{y\in\{x\}} f\, y\\ &= \lambda f.f\, x\end{aligned}$$

Does the result look familiar to you?

The interaction of η and $\ggg$

What do you notice about the following:

$$\begin{aligned}(\eta\, x)^{\ggg} &= \lambda f.\, \bigcup_{y \in \{x\}} f\, y \\ &= \lambda f.\, f\, x\end{aligned}$$

Does the result look familiar to you? $\lambda f.\, f\, x$ is just **LIFT** applied to x!

In other words, η and $\ggg$ are a *decomposition of* **LIFT**:

$$\ggg \circ\, \eta = \textbf{LIFT}$$

Replacing the Partee triangle?

+**wh**

$$
\begin{tikzcd}
(a \to \mathtt{t}) \to \mathtt{t} & & a \arrow[ll, "\mathbf{LIFT}_{t}"'] \arrow[rr, "\mathbf{LIFT}_{\mathsf{S}\,b}"] \arrow[d, "\eta"] & & (a \to \mathsf{S}\,b) \to \mathsf{S}\,b \\
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\end{tikzcd}
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One more question about η and $\gg=$

What do you notice about the following?

$$m \gg= \eta$$

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One more question about η and $\gg=$

What do you notice about the following?

$$\begin{aligned} m \gg= \eta &= \textstyle\bigcup_{x \in m} \eta\, x \\ &= \textstyle\bigcup_{x \in m} \{x\} \\ &= m \end{aligned}$$

In other words, then, $\lambda m.\, m \gg= \eta$ is... **an identity function, $\lambda m.\, m$.**

And one question, just about $\gg=$

What do you notice about the following?

$$m \gg= \lambda n.\, n$$

And one question, just about $\gg=$

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$$m \gg= \lambda n.\, n = \bigcup_{x \in m} x$$

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Interesting! Putting m and the *identity function* together via $\gg=$ has the effect of collapsing m into a flatter alternative set. So what must the type of m be here?

And one question, just about $\ggg$

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$$\mathsf{S}\,(\mathsf{S}\,a)$$

Very interesting, higher-order meanings! How might we get *those*?

Islands

How about islands?

Like Karttunen, our account is oriented around scope-taking. This seems to suggest that, like Karttunen, the account doesn't really allow for alternative percolation out of islands.

That seems... bad.

On the properties of $\gg\!=$

So one last exercise:

$$(m \gg\!= \lambda x.\, f\, x) \gg\!= g = m \gg\!= (\lambda x.\, f\, x \gg\!= g)$$

Can you convince yourself of the correctness of this equation? Can you think of any consequences it might have for island-hood?

And back to the mission

So after exploring a few possibilities, we converged on a treatment of indefinites (and wh) as sets that used η and $\ggcurly$ in lieu of some of the other approaches out there.

- Partee's **A** shifter
- Alternative semantics
- Karttunen (with a +wh)
- Hybrid approaches

We explored some properties of η and $\ggcurly$, too.

Now, permit yourself to think a bit more generally. Can η and $\ggcurly$ also help us understand some of the other domains we were interested in?

- Is *this* the abstraction we were looking for?

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