Exceptional *de re* in continuation semantics

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1. Desiderata for a theory of *de re/de dicto*

How should *intensionality* be incorporated into the grammar, in a principled way? As it stands, there are two main approaches: the Binding Theory of Intensionality (BTI) and the Scope Theory of Intensionality (SCOPTI). The BTI is the more powerful of the two approaches — it makes use of world pronouns in the object language, alongside a rule for abstracting over variables. As shown by Percus (2000), such a theory must be supplemented with an apparently ad-hoc binding theory for world pronouns, which bears little resemblance to independently motivated restrictions on anaphora.

Furthermore, as shown convincingly by Romoli & Sudo (2009), such a theory over-generates readings for configurations involving nested Determiner Phrases (DPS), as in (1). Romoli & Sudo show in detail that (1) lacks a reading where *president* is interpreted *de dicto*, and *wife* is interpreted *de re*. This reading can nevertheless easily be derived on the BTI.

(1)   Mary thinks that [the wife of [the president]] is nice.   ✗ *wife*$_{de\ re}$; *president*$_{de\ dicto}$

This brings us to the other prominent approach to intensionality in the grammar — the SCOPTI. According to the SCOPTI, *de re* readings are achieved via independently-motivated mechanisms for scoping DPS. A number of the constraints on *de re* readings which must be stipulated in the BTI fall out as a matter of course from a scope theory (see Keshet 2008, 2011 for discussion). The unattested mixed reading of (1) falls out straightforwardly on the SCOPTI, since scoping DP container necessitates scoping the contained material (see Elliott 2020, Romoli & Sudo 2009 for discussion).

While the BTI faces over-generation issues, the SCOPTI faces under-generation issues. Seemingly the most damning of these is that restrictions on quantificational scope don't seem to track restrictions on *quantificational* scope. Quantificational scope is roofed by finite clauses and other scope islands, as illustrated in (2).

(2)   Exactly two philosophers think [that every linguist is drunk].   ✗ ∀ > 2

De re readings, on the other hand, are not roofed by scope islands. In (3), "the linguist" can be interpreted *de re*. Following Demirok (2019), we'll refer to this phenomenon as *exceptional de re*.

(3)   Roger thinks that [the linguist is drunk].   ✓ *linguist*$_{de\ re}$

Keshet (2011) develops an approach to exceptional *de re* couched within the SCOPTI. Keshet's account however is limited to cases involving a single level of embedding. Grano (2019) and Elliott (2020) have recently argued that exceptional *de re* readings are in principle unbounded.

It seems like (what we may refer to as) the *intensional effects* of an expression do not track restrictions on quantificational scope. Further to this point, it seems as if the self-same expression may scope at different points for the purposes of its intensional and quantificational effects[1]. This is illustrated most strikingly by Fodor's (1970) *non-specific de re reading*. Consider (4). The reading of interest can be paraphrased roughly as: *Mary has a desire to buy any hat that satisfies a particular condition, e.g., one that suits her. Unbeknownst to Mary, my hat happens to suit her. She may not be aware of it, but her*

[1] We'll frequently talk about the intensional/quantificational "effects" of an expression. This is inspired by an analogy with computational side-effects in programming languages, put forward by Shan (2005).

desires encompass my hat.. It has been suggested (see, e.g., Heim & von Fintel 2011) that the Logical Form (LF) for this reading should involve an existential taking narrow scope below *want*, with the restrictor nevertheless interpreted *de re*. On a naïve conception of the ScopTI, this would be a scope paradox.

(4)   Mary wants to buy a hat just like mine.   want > ∃; *a hat just like mine*$_{de\ re}$

An emerging consensus is that (a) quantificational and intensional effects may scope together, or (b) the intensional effects of an expression may *out-scope* its quantificational effects. See Elliott (2020), Keshet & Schwarz (2019) for detailed argumentation, and Szabó (2010) for a dissenting view.

There is a gap in the market, therefore, for a scopal approach to intensionality, that inherits the advantages of previous scope theories while addressing the possibility of exceptional *de re*, and which furthermore allows intensional effects to out-scope quantificational effects. Arguably, Demirok's (2019) ∃−theory, which accounts for exceptional *de re* via recursive pied-piping, achieves these goals. Demirok's account would assign (3) the LF in (5) (eliding some details):

(5)   [[the linguist]^1 [t_1 is drunk]]^2 Roger thinks t_2.   *linguist*$_{de\ re}$

There are a number of reasons to be dissatisfied with Demirok's approach however. It flouts constraints on pied-piping which can be observed in, e.g., English, for overt movement. There is, therefore, scant evidence for the syntactic reality of these movement operations. Furthermore, given the independently necessary possibility of semantic reconstruction, Demirok must stipulate that non-nominal constituents, such as VPs, may not undergo covert movement, in order to rule out unattested readings.

The purpose of this short paper is not to argue against Demirok's approach (but see Elliott 2020 for critical discussion), but rather to lay out a scopal theory of intensionality couched within a non-movement approach to scope-taking: *continuation semantics*. Here, we'll aim to integrate continuation semantics with the monadic approach to linguistic side-effects (Charlow 2014, Shan 2005). In part, this will be an exercise in figuring out just how simple our theory of semantics can be. In other words, how many primitive operations do we need to posit in order to capture the desiderata outlined in this section? It will turn out that the set of primitives we need will be surprisingly small, and a careful consideration of this question will unveil some otherwise unexpected connections.

2. From world-sensitivity to exceptional *de re*
2.1. Bootstapping an intensional fragment with `Reader`

In order to model intensionality, it's common to assume that the interpretation function $[\![.]\!]$ is relativized to a world parameter. Equivalently, we can simply assume that the interpretation function delivers world-sensitive values right off the bat (see Heim & von Fintel 2011 for discussion). We can characterize the space of world-sensitive values via a type constructor, S, defined in (6).

(6)   `Reader` for world sensitivity (def.): S a ≔ s → a

World-sensitivity is just one kind of environment sensitivity — a pervasive phenomenon in natural language semantics. In work on *side-effects*, environment sensitivity is typically modeled via `Reader`. For a given environment type r, `Reader` a is just r → a, i.e., a familiar function type. One straightforward way of achieving a fragment with the expressive power to model intensional phenomena, is to assume that predicates return *propositions* rather than truth-values. This is illustrated for the predicate "swim", below:

(7) $[\![\text{swim}]\!] ≔ \lambda x w . \text{swim}_w\, x$ e → S t

Currying the individual and world arguments in this particular way was not an arbitrary choice — a straightforward consequence is that, assuming that names denote individuals, and are therefore of type e,[2] semantic composition can proceed via plain old Function Application (FA).[3]

(8) $[\![\text{John swims}]\!] = [\![\text{John}]\!] \; \text{A} \; [\![\text{swims}]\!] = (\lambda xw \,.\, \text{swim}_w \, x) \, \text{john} = \boxed{\lambda\, w \,.\, \text{swim}_w \, \text{john}}$ S t

Unlike names, definite descriptions give rise to *de re*/*de dicto* ambiguities, and therefore the semantics of a definite description must be inherently world sensitive. Assuming a Fregean analysis of definite descriptions (i.e., they denote individuals), there becomes really only one way of implementing this — definite descriptions must come with an outer world argument.[4]

(9) $[\![\text{the boy}]\!] = \lambda w \,.\, \iota x[\text{boy}_w \, x]$ S e

The careful reader will already have noted that the semantics we've given for "the boy" (9) can't compose with a simple predicate such as "swim" (7). This will motivate a key component of our intensional fragment: (monadic) *bind*. Perhaps surprisingly, this additional operation, independently motivated by a straightforward composition puzzle, will *predict* the possibility of exceptional *de re*.

2.2. Monadic bind and scope

Below, we define the operation which will allow a definite description to compose with a simple predicate.

(10) Monadic bind (def.)
$m^{\star} := \lambda k \,.\, \lambda w \,.\, k \, (m \, w) \, w$ $\text{R}_{\text{s}} \; \text{a} \to (\text{a} \to \text{S b}) \to \text{S b}$

Bind takes a world sensitive *a*, and returns a higher-order function. Bind can be defined in a natural way, because `Reader` is a *monad* — a widely used mathematical construct for modeling effectful computation (see Shan 2005 a.o., for discussion). The resulting meaning is a function from a *continuation argument k* to a world sensitive *b* (we'll explain what we mean by "continuation argument" very soon). A bind-shifted definite description may now straightforwardly compose with a predicate via FA; the predicate simply saturates the continuation argument of the bind-shifted definite. Subsequently, the description is fed into the predicate by first saturating the world argument of the description — the outputted proposition has its world argument *re-* saturated.

(11) $[\![\text{the boy swims}]\!] = [\![\text{the boy}]\!]^{\star} \; \text{A} \; [\![\text{swims}]\!] = (\lambda w \,.\, \iota x[\text{boy}_w \, x])^{\star} \, (\lambda xw \,.\, \text{swim}_w \, x)$ S t
$= (\lambda kw \,.\, k \, (\iota x[\text{boy}_w \, x]) \, w) \, (\lambda xw \,.\, \text{swim}_w \, x)$
$= \lambda w \,.\, \text{swim}_w \, \iota x[\text{boy}_w \, x]$

While bind allows descriptions in subject position quite straightforwardly, as the reader can verify applying bind to a description in *object* position fails to resolve the type mismatch — we need a mechanism for *scoping out* the description, by abstracting over a variable of type e. This is schematized below:

(12) ✓ $[\![\text{the boy}]\!]^{\star} \, (\lambda x \,.\, \text{mary} \; \text{hug} \; x)$

As emphasized by Barker & Shan (2014), scope-takers in general have a type of the form $(\text{a} \to \text{r}) \to \text{r}$, where r is the *return type*. The type of a bind-shifted description matches this schema, where the return type is intensional. In order to fully incorporate monadic bind into our fragment we therefore need a mechanism for incorporating scope-takers into our fragment – enter *continuation semantics*.

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[4] The final version of our analysis will be compatible with both the Fregean and Russellian approach to definite descriptions. Since quantificational expressions add complexity to the discussion however, it will be presentationally convenient to start with the Fregean picture.

2.3. Continuation semantics

Continuation semantics, developed in various works by Chris Barker and Chung-chieh Shan (Barker 2002, Barker & Shan 2008, 2014, Shan & Barker 2006) constitutes a general framework for modeling scope in natural language. Note that we won't have time to give a full introduction to the framework here, beyond briefly introducing tower notation; see Barker & Shan 2014 for an excellent introductory text. As mentioned in the previous section, scope-takers fit a general type schema: $(a \to r) \to r$. Consider, e.g., the semantics of a Quantificational Phrase (QP) such as "every boy":

(13) $[\![\text{every boy}]\!] := \lambda k . \forall x[\text{boy } x \to k\ x]$ $(e \to t) \to t$

Tower notation is used to abbreviate scopal values; the tower abbreviation for "every boy" is given below. The argument of the continuation k appears on the bottom of the tower; on the top of the tower the result of applying the continuation k to its argument is represented as a hole [].

(14) $[\![\text{every boy}]\!] = \dfrac{\forall x[\text{boy } x \to [\ ]]}{x}$

Scope-takers compose *in-situ* via an enriched form of FA that keeps track of the scopal *side-effects* of expressions (16), in addition to an operation that lifts non-scope-takers into trivial scope-takers (**??**). We'll abbreviate scopal types as follows:

(15) Type constructor for continuations (def.): $K_r\ a := (a \to r) \to r$

(16) Scopal Function Application (SFA) (def.): $\dfrac{f\ [\ ]}{x} \circledast \dfrac{g\ [\ ]}{y} := \dfrac{f\ [g\ [\ ]]}{x\ a\ y}$

(17) Lift (def.): $x^{\uparrow} := \dfrac{[\ ]}{x}$ $\uparrow: a \to K_r\ a$

There is one last thing which is relevant to mention: when the return type and the "contained" type match, the tower may be "collapsed" into a non-scopal value by saturating the continuation argument with the identity function. We call this operation lower; it is defined in (18).

(18) Lower (def.): $\left(\dfrac{f\ [\ ]}{p}\right)^{\downarrow} := f\ p$ $\downarrow: K_r\ r \to r$

Now, consider again the type of a bind-shifted description — $(e \to S\ b) \to S\ b$. Note that it fits the scopal type schema. We can rewrite it as $K_{S\ b}\ e$. This means that bind-shifted descriptions are *scope-takers* and can enter into semantic composition via SFA. We can even recast a bind-shifted definite — an example is repeated below — using Barker & Shan's tower notation.[5]

(20) $[\![\text{the boy}]\!]^{\star} = \lambda k w . k\ (\iota x[\text{boy}_w\ x])\ w \equiv \dfrac{[\![\text{the boy}]\!]^{\star}\ (\lambda x . [\ ])}{x}$ $K_{S\ b}\ e$

To go back to our original problem, bind-shifted descriptions in object position may now compose via SFA. The result is collapsed into a *proposition* via the lower operation defined in the previous section. If there are multiple bind-shifted descriptions, they are relativized to the same world. This is illustrated in the derivation in figure (1).

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[5] This recasting relies on the following equivalence, which we'll take frequent advantage of in what follows:

(19) $m^{\star} \equiv m^{\star}\ (\lambda x . x^{\uparrow})$

Figure (1): Deriving "the girl hugged the boy" via continuation semantics.

$$\lambda w . \iota y[\text{girl}_w\ y]\ \text{hug}_w\ \iota x[\text{boy}_w\ x]$$

equiv. |

$$[\![\text{the girl}]\!]^\star\ (\lambda y .\ [\![\text{the boy}]\!]^\star\ (\lambda x . \lambda w .\ y\ \text{hug}\ x))$$

$\downarrow$ |

$$\underline{[\![\text{the girl}]\!]^\star\ (\lambda y .\ ([\![\text{the boy}]\!]^\star\ (\lambda x . [])))}$$
$$\lambda w .\ y\ \text{hug}\ x$$

$$\underline{[\![\text{the girl}]\!]^\star\ (\lambda y . [])} \qquad \underline{[\![\text{the boy}]\!]^\star\ (\lambda x . [])}$$
$$y \qquad\qquad\qquad \lambda y w .\ y\ \text{hug}_w\ x$$

$$\star\ | \qquad\qquad\qquad\qquad\qquad$$

$$\text{the girl} \qquad \underline{[]} \qquad \underline{[\![\text{the boy}]\!]^\star\ (\lambda x . [])}$$
$$\text{hug} \qquad\qquad x$$

$$\uparrow\ | \qquad\qquad \star\ |$$

$$\text{hug} \qquad\qquad \text{the boy}$$
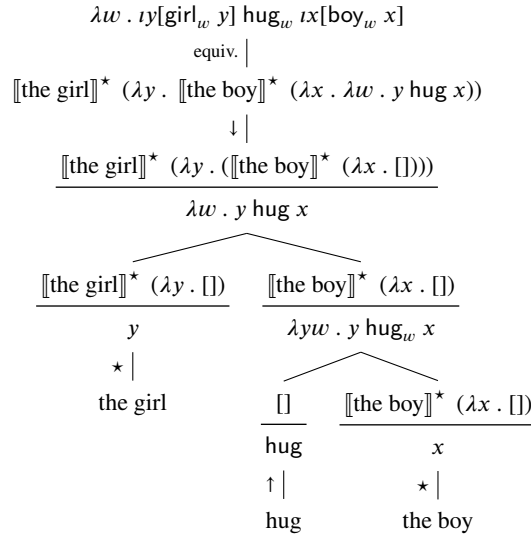
As emphasized by the *lowered* representation, continuation semantics allows us to compositionally construct LFS in which bind-shifted descriptions are scoped out, as schematized in (21). Where appropriate, we will therefore gloss over the niceties of the continuation semantic derivation, and skip straight to the scoped representation.

(21) $[\![\text{the girl}]\!]^\star\ (\lambda y .\ [\![\text{the boy}]\!]^\star\ (\lambda x . \lambda w .\ y\ \text{hug}\ x))$

3. Accounting for *de re*/*de dicto* ambiguities

Given *lower*, we now have everything we need in order to account for simple *de re*/*de dicto* ambiguities with definite descriptions, by using bind in tandem with continuation semantics. Consider e.g., a sentence such as the following:

(22)   Mary wants to meet the lawyer.

Let's assume that the attitude verb "want" takes a proposition (type $\mathsf{S}\ t$) as its argument, and introduces a new layer of world sensitivity:

(23) $[\![\text{want}]\!] = \lambda p x w .\ x\ \text{want}_w\ p$ $\qquad\qquad\qquad\qquad\qquad\qquad$ $\mathsf{S}\ t \to e \to \mathsf{S}\ t$

Given an orthodox syntactic structure, there are (at least) two convergent semantic derivations, both of which involve bind-shifting the description. We can compose the description via SFA and lower it before the attitude verb has entered into the derivation, in which case we get the *de dicto* interpretation (24), or we can defer lowering until after *want* has entered into the derivation, in which case we get the *de re* interpretation (25).

(24) $[\![\text{Mary wants to meet the lawyer}]\!] = [\![\text{Mary}]\!]\left([\![\text{want}]\!]\left(\dfrac{[\![\text{the lawyer}]\!]^\star\ (\lambda x . [])}{\lambda w' .\ \mathsf{m}\ \text{meet}_{w'}\ x}\right)^{\downarrow}\right)$

$\qquad\qquad = [\![\text{Mary}]\!]\ ([\![\text{want}]\!]\ ([\![\text{the lawyer}]\!]^\star\ (\lambda x w' .\ \mathsf{m}\ \text{meet}_{w'}\ x)))$

$\qquad\qquad = [\![\text{Mary}]\!]\ ([\![\text{want}]\!]\ (\lambda w' .\ \mathsf{m}\ \text{meet}_{w'}\ \iota x[\text{lawyer}_{w'}\ x]))$

$\qquad\qquad = \lambda w .\ \mathsf{m}\ \text{want}_w\ (\lambda w' .\ \mathsf{m}\ \text{meet}_{w'}\ \iota x[\text{lawyer}_{w'}\ x])$

(25) $\llbracket$Mary wants to meet the lawyer$\rrbracket = \left(\dfrac{\llbracket\text{the lawyer}\rrbracket^{\star}\ (\lambda x\ .\ [])}{\lambda w\ .\ \mathsf{m}\ \mathsf{want}_w\ (\lambda w'\ .\ \mathsf{m}\ \mathsf{meet}_{w'}\ x)} \right)^{\downarrow}$

$= \llbracket\text{the lawyer}\rrbracket^{\star}\ (\lambda xw\ .\ \mathsf{m}\ \mathsf{want}_w\ (\lambda w'\ .\ \mathsf{m}\ \mathsf{meet}_{w'}\ x))$

$= \lambda w\ .\ \mathsf{m}\ \mathsf{want}_w\ (\lambda w'\ .\ \mathsf{m}\ \mathsf{meet}_{w'}\ \iota x[\mathsf{lawyer}_w\ x])$

Before moving onto *exceptional de re*, it is worth dwelling for a moment on how to cash out scope-islands within continuation semantics. Here, we assume Charlow's (2014) denotational theory of scope-islands, according to which a scope-island must denote a *fully lowered* type. This ensures that, in computing the meaning of (26), evaluating the scope of "every show" *cannot* be deferred until after "hope" has entered into the derivation. This restriction does not affect our account of the *de re* interpretation of descriptions, as in (3), since it's independently known that non-finite clauses (at least, the complement of *want*) are not scope islands.

(26) Exactly three art critics want to review $\boxed{\text{every show}}$. ✓ ∀ > 3

An apparent problem with our account of *de re* is that *de re* interpretations are apparently immune to scope-islands (exceptional *de re*). As we'll see, this problem is in fact only illusory. Bind, in tandem with an extremely simple lifting operation, which we define in the next section, will be sufficient in order to derive exceptional *de re* interpretations, while maintaining Charlow's account of scope islands.

4. Accounting for exceptional *de re*

It's helpful to keep track of the type-shifters/composition rules we've posited so far: *bind* shifts a world-sensitive value into a scope-taker, sfa allows for in-situ composition of scope-takers, *lift* shifts a value into a trivial scope-taker, and *lower* evaluates scope. We will only need one further ingredient in order to account for exceptional *de re* readings of descriptions — an operation that shifts a value into a trivially world-sensitive value, i.e., *up*, defined below.[6]

(27) Up (def.): $x^{\wedge} := \lambda w\ .\ x$ $\qquad\qquad \wedge : \mathsf{a} \to \mathsf{S}\ \mathsf{a}$

Recall that, in continuation semantics, in order to apply a function to the bottom of a tower, we must first lift the function, and compose via sfa. In the following, we will often need to apply up to the bottom of a tower. In order to simplify the resulting derivations, we will overload the definition of up such that it may apply directly to a scopal value:

(28) $\left(\dfrac{f\ []}{x} \right)^{\wedge} \equiv \dfrac{f\ []}{x^{\wedge}}$ $\qquad\qquad \wedge : \mathsf{K}_r\ \mathsf{a} \to \mathsf{K}_r\ (\mathsf{S}\ \mathsf{a})$

In order to show how we can account for exceptional *de re*, we give a concrete example in figure (2).
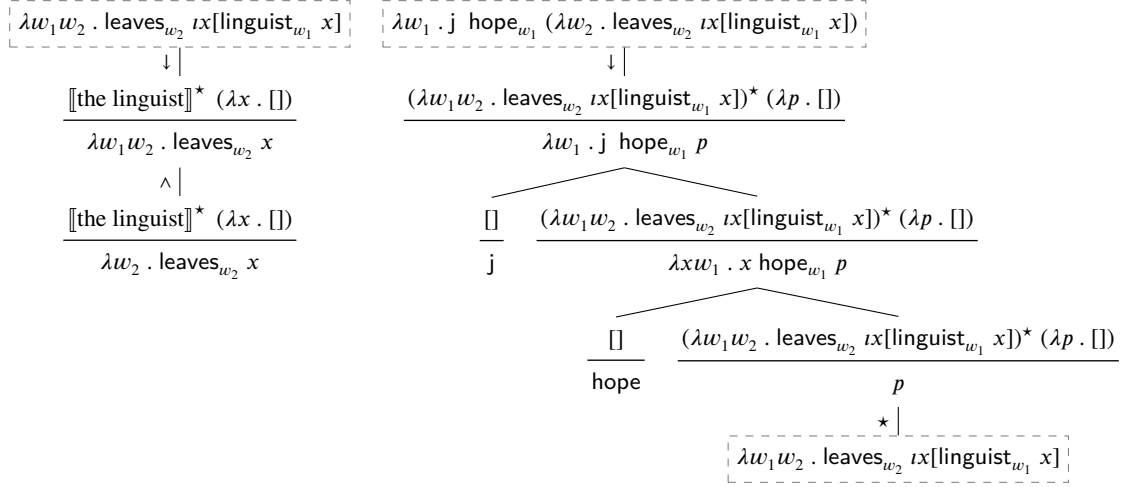
5. Integrating quantificational determiners

So far, we've intentionally steered clear of quantificational determiners such as *every*, *most*, etc. This wasn't accidental, as incorporating quantification into our system will necessitate an unavoidable complication. In turns out, however, that if we complicate things in *just* the right way, we'll make powerful (and, I'll suggest, *good*) predictions concerning the interaction between *quantificational* and *intensional* scope.

Consider first a standard type for a quantificational determiner, (29). Assuming that nominal predicates are of type $\mathsf{e} \to \mathsf{S}\ \mathsf{t}$, there's no obvious way of composing the determiner with its restrictor. Bind won't help (the reader can verify this for themselves).

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[6] The careful reader will note a family resemblance between the *up* operator, and *lift* in continuation semantics. This is no accident – S and K_r are both *monads*; up and lift are correspond to the `return` function associated with the respective monads.

Figure (2): "Josie hopes that the linguist leaves"

$$\lambda w_1 w_2 . \text{leaves}_{w_2} \iota x[\text{linguist}_{w_1} x]$$

$\downarrow|$

$$\frac{[\![\text{the linguist}]\!]^\star \ (\lambda x . [])}{\lambda w_1 w_2 . \text{leaves}_{w_2} x}$$

$\wedge|$

$$\frac{[\![\text{the linguist}]\!]^\star \ (\lambda x . [])}{\lambda w_2 . \text{leaves}_{w_2} x}$$

$$\lambda w_1 . j \text{ hope}_{w_1} (\lambda w_2 . \text{leaves}_{w_2} \iota x[\text{linguist}_{w_1} x])$$

$\downarrow|$

$$\frac{(\lambda w_1 w_2 . \text{leaves}_{w_2} \iota x[\text{linguist}_{w_1} x])^\star \ (\lambda p . [])}{\lambda w_1 . j \text{ hope}_{w_1} p}$$

$$\frac{[] \qquad (\lambda w_1 w_2 . \text{leaves}_{w_2} \iota x[\text{linguist}_{w_1} x])^\star \ (\lambda p . [])}{j \qquad \lambda x w_1 . x \text{ hope}_{w_1} p}$$

$$\frac{[] \qquad (\lambda w_1 w_2 . \text{leaves}_{w_2} \iota x[\text{linguist}_{w_1} x])^\star \ (\lambda p . [])}{\text{hope} \qquad p}$$

$\star|$

$$\lambda w_1 w_2 . \text{leaves}_{w_2} \iota x[\text{linguist}_{w_1} x]$$

(29) $[\![\text{every}]\!] : (e \rightarrow t) \rightarrow (e \rightarrow t) \rightarrow t$

In order to understand how determiners can be integrated into our fragment, it will be useful to first consider how determiners can be integrated into continuation semantics. As emphasized by Barker & Shan (2014) (and see especially Wadler 1994), the type-schema we've been using to model scope-takers $(a \rightarrow r) \rightarrow r$ is more specific than it needs to be, given the continuation semantic composition rules. Concretely, it assumes that the *expected type* — the type at which scope can be evaluated — and the *return type* — the type returned post-evaluation — are the same. We can however generalize, and allow these two types to differ: $(a \rightarrow i) \rightarrow r$. This allows us to think of *every* as itself a scope-taker, which *expects* something of type t and *returns* a scope-taker of type K_t e. The only changes we need to make to our composition schema is to make the types of lift, sfa, and lower more general, as below (the definitions of these operations remain the same). We abbreviate a type of the form $(a \rightarrow i) \rightarrow r$ as K_r^i.[7]

(30) a. $\uparrow: a \rightarrow K_r$

   b. $\circledast : K_r^i (a \rightarrow b) \rightarrow K_i^j a \rightarrow K_r^j b \ / \ K_r^i (a) \rightarrow K_i^j (a \rightarrow b) \rightarrow K_r^j b$

   c. $\downarrow: K_r^i i \rightarrow r$

We can now write our entry for *every* using tower notation:

(31) $$\frac{[\![\text{every}]\!] \ (\lambda x . [])}{x} \qquad\qquad K_{K_t \ e}^t \ e$$

In a classical setting, *everu* may compose with its restrictor via sfa; lowering the result gives us back a standard continuation-semantic entry for a qp. In order to allow a determiner to compose with a restrictor in an intensional fragment however, we need to shift the determiner. We do this via a new operation *transform*.

(32) Transform (def)
   $$m^\tau = \lambda k w . m \ w \ (\lambda x . k \ x \ w) \qquad\qquad \tau : S \ (K_r^i a) \rightarrow K_{S \ r}^{S \ i} a$$

We can re-write transform using tower notation like so:

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[7] When the expected and return types are the same, e.g., r, we simply write K_r.

Figure (3): Composing a quantificational determiner with its restrictor

$$\lambda w \, . \, \frac{\forall x[\text{boy}_w \, x \rightarrow []]}{x}$$

equiv. $\Big|$

$$\lambda w \, . \, [\![\text{every}]\!] \; (\lambda x \, . \, \text{boy}_w \, x)$$

$\downarrow \Big|$

$$\frac{\lambda w \, . \, [\![\text{every}]\!] \; (\lambda x \, . \, ([] \, w))}{\lambda w' \, . \, \text{boy}_{w'} \, x}$$

$$\circledast$$

$$\frac{\lambda w \, . \, [\![\text{every}]\!] \; (\lambda x \, . \, ([] \, w))}{x} \qquad \frac{[]}{\lambda x w' \, . \, \text{boy}_{w'} \, x}$$

$\tau \circ \wedge \Big| \qquad\qquad\qquad\qquad \uparrow \Big|$

every $\qquad\qquad\qquad\qquad$ boy

(33) Transform (tower ver.)

$$m^\tau = \frac{\lambda w \, . \, m \, w \, (\lambda x \, . \, ([] \, w))}{x}$$

In order to transform *every*, it must first be shifted into a trivially intensional determiner via up. The result can be transformed, giving back the following:

(34) $\displaystyle [\![\text{every}]\!]^{\tau \circ \wedge} = \frac{\lambda w \, . \, [\![\text{every}]\!] \; (\lambda x \, . \, ([] \, w))}{x}$ $\qquad\qquad$ $K^{S\,t}_{S\,(K_t\,e)}\, e$

Every and its restrictor may now compose via SFA, and lowering the result gives back a world sensitive scope-taker, as shown in figure (3).

6. Intensional vs. quantificational scope

We've shown how determiners may compose with their restrictors in an intensional fragment, via a generalization of the machinery we use for modeling *scope*, alongside a novel operation *transform*. We still need to say something about how the result of composing a determiner with its restrictor — a world-sensitive scope-taker — plays with the rest of our fragment. Perhaps surprisingly, the operations we've already posited — specifically bind and transform — will result in a system that is sufficiently expressive to account for interactions between quantificational and intensional scope. Concretely, what we'll end up predicting is that the *intensional effects* associated with an expression may outscope its *quantificational effects*, but not vice versa.

The core insight will be as follows — if we apply *transform* to a world-sensitive QP, we predict that intensional and quantificational effects will scope together.

(35) $\displaystyle \left(\lambda w \, . \, \frac{\forall x[\text{boy}_w \, x \rightarrow []]}{x} \right)^\tau = \frac{\lambda w \, . \, \forall x[\text{boy}_w \, x \; \rightarrow \; ([] \, w)]}{x}$ $\qquad\qquad$ $K_{S\,t}\, e$

The possibility of transforming a QP predicts Fodor's (1970) *specific de re* and *non-specific de dicto* readings, depending on whether the transformed QP scopes above or below an intensional operator. In our terms, quantificational and intensional effects associated with an expression may scope together. This is illustrated below:

(36) Specific *de re*

[[Mary wanted to buy a hat just like mine]] .

= [[a hat just like mine]]$^\tau$ $(\lambda x w_1 . \text{m want}_{w_1} (\lambda w_2 . \text{m buy}_{w_2} x))$

= $\lambda w_1 . \exists x[\text{hat-just-like-mine}_{w_1} x \wedge \text{m want}_{w_1} (\lambda w_2 . \text{m buy}_{w_2} x)$

(37) Non-specific *de dicto*

[[Mary wanted to buy a hat just like mine]]

= [[Mary]] ([[want]] ([[a hat just like mine]]$^\tau$ $(\lambda x w_2 . \text{m buy}_{w_2} x)))$

= [[Mary]] ([[want]] $(\lambda w_2 . \exists x[\text{hat-just-like-mine}_{w_2} x \wedge \text{m buy}_{w_2} x])$

= $\lambda w_1 . \text{m want}_{w_1} (\lambda w_2 . \exists x[\text{hat-just-like-mine}_{w_2} x \wedge \text{m buy}_{w_2} x])$

It's been noticed however, that the example under consideration has a third reading, where the existential takes wide-scope, despite the fact that the NP restrictor is interpreted *de re*. Our grammar already has the expressive power to capture this reading, we need only recognize that, as well as transforming a world-sensitive QP, we may also apply bind to it, since the type signature fits the schema of S a (type S $(K_t e)$, to be precise). Applying bind to "a hat just like" mine results in a higher-order scope-taker, as illustrated below:

(38) $[[\text{a hat just like mine}]]^\star \equiv \dfrac{[[\text{a hat just like mine}]]^\star \ (\lambda Q . [])}{\dfrac{Q \ (\lambda x . [])}{x}}$ $\qquad\qquad$ $K_{S\,t} (K_t e)$
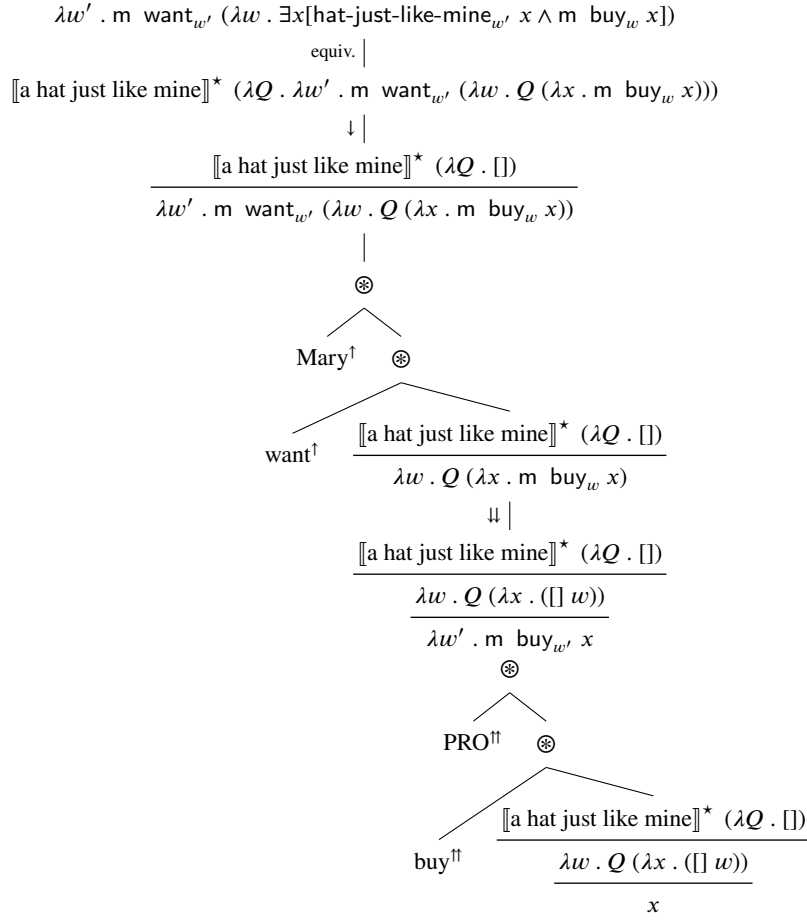
Since the bottom of the tower is itself a scope-taker, we may up-shift and transform it:

(39) $\dfrac{[[\text{a hat just like mine}]]^\star \ (\lambda Q . [])}{\left(\dfrac{Q \ (\lambda x . [])}{x}\right)^{\tau \circ \wedge}}$ = $\dfrac{[[\text{a hat just like mine}]]^\star \ (\lambda Q . [])}{\dfrac{\lambda w . Q \ (\lambda x . ([] \ w))}{x}}$ $\qquad$ $K_{S\,t} (K_{S\,t} e)$

It's helpful to think of the result as (potentially) a *split-scope-taker*. The intensional side-effects associated with the QP may be evaluated at the same stage as the quantificational side-effects are evaluated, or at some later stage in the derivation. We can account for Fodor's *third reading* (non-specific *de re*) using the semantics in (6), by lowering the bottom of the tower before the intensional verb enters into the derivation, and the top of the tower after. This is illustrated in figure (4).[8]

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[8] Out of necessity, some of the details of the derivation in figure (4) have been elided. $x^{\dagger\dagger}$ means that lift has been applied to x twice. $\Downarrow$ stands for Barker & Shan's *internal* lower (i.e., lifted lower), which allows us to lower the bottom half of a tower.

Figure (4): Accounting for Fodor's "third reading"

$$\lambda w' \,.\, \mathsf{m}\ \mathsf{want}_{w'}\ (\lambda w \,.\, \exists x[\text{hat-just-like-mine}_{w'}\ x \wedge \mathsf{m}\ \mathsf{buy}_w\ x])$$

equiv.

$$[\![\text{a hat just like mine}]\!]^{\star}\ (\lambda Q \,.\, \lambda w' \,.\, \mathsf{m}\ \mathsf{want}_{w'}\ (\lambda w \,.\, Q\ (\lambda x \,.\, \mathsf{m}\ \mathsf{buy}_w\ x)))$$

$\downarrow$

$$\frac{[\![\text{a hat just like mine}]\!]^{\star}\ (\lambda Q \,.\, [])}{\lambda w' \,.\, \mathsf{m}\ \mathsf{want}_{w'}\ (\lambda w \,.\, Q\ (\lambda x \,.\, \mathsf{m}\ \mathsf{buy}_w\ x))}$$

$\circledast$

Mary†　$\circledast$

want†

$$\frac{[\![\text{a hat just like mine}]\!]^{\star}\ (\lambda Q \,.\, [])}{\lambda w \,.\, Q\ (\lambda x \,.\, \mathsf{m}\ \mathsf{buy}_w\ x)}$$

$\Downarrow$

$$\frac{[\![\text{a hat just like mine}]\!]^{\star}\ (\lambda Q \,.\, [])}{\lambda w \,.\, Q\ (\lambda x \,.\, ([]\ w))}$$

$$\lambda w' \,.\, \mathsf{m}\ \mathsf{buy}_{w'}\ x$$

$\circledast$

PRO††　$\circledast$

buy††

$$\frac{[\![\text{a hat just like mine}]\!]^{\star}\ (\lambda Q \,.\, [])}{\lambda w \,.\, Q\ (\lambda x \,.\, ([]\ w))}$$

$$x$$

7. Conclusion

In this short paper, we've investigated the following question, with a focus on intensionality: just how simple can our semantic theory be? We've uncovered some perhaps unexpected logical connections between the primitive operations we've defined. *Bind* was motivated by the straightforward compositionality puzzle of combining definite descriptions and predicates; the bind operation *predicts* that world-sensitive expressions take scope, since it returns a scope-taker in the continuation semantic schema. Alongside our up-operator, bind gives rise, as a matter of course, to the possibility of exceptional *de re* — this is because, due to the polymorphism of bind, scope-islands themselves may be bind-shifted into scope-takers. Similarly, *transform* was motivated by the straightforward compositionality puzzle of combining quantificational determiners with restrictors. Transform *predicts* that quantificational effects and intensional effects can scope together, since applying transform to a world-sensitive QP returns a scope-taker with an intensional return type. Strikingly, applying *bind* to a world-sensitive scope-taker gives rise to a hybrid scope-taker, where intensional effects outscope quantificational effects; other accounts of the third reading must make recourse to semantic reconstruction via higher-type traces (see, e.g., Demirok 2019, Heim & von Fintel 2011).

The approach to intensionality outlined here connects to a growing body of work using *monads* to model linguistic side-effects (see, e.g., Charlow 2014, Shan 2005, a.o.). Concretely, we've made use of the `Reader` monad for environment sensitivity, and the `Cont` monad for scope. The connection to monads has been left largely implicit, but see Elliott (2020) for an elaboration. The result is an intensional fragment which, arguably, slices the pie in *just* the right way, without complicating the narrow syntax

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