Split-scope definites: Relative superlatives and Haddock descriptions

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Abstract This paper argues for a particular semantic decomposition of morphological definiteness. I propose that ⟦the⟧ comprises two distinct compositional operations. The first builds a set of witnesses that satisfy the restricting NP. The second tests this set for uniqueness. The motivation for decomposing the denotation of the definite determiner in this way comes from split-scope intervention effects. The two components — the selection of witnesses on the one hand and the counting of witnesses on the other — may take effect at different points in the composition of a constituent, and this has non-trivial semantic consequences when other operators inside the DP take action in between them. In particular, I analyze well-known examples of mutually recursive definite descriptions like 'the rabbit in the hat' (when there are two rabbits and two hats but only one rabbit in a hat and only one hat with a rabbit in it) as examples of definites whose referent-introducing and referent-testing components are interleaved rather than nested. I further demonstrate that this picture leads to a new theory of so-called *relative superlative* descriptions like 'the kid who climbed the highest tree' (when there is no highest tree, per se, only a highest tree-climbing kid), a theory which *explains* the previously mysterious role of the definite determiner in licensing such readings.

1 Introduction

Definite determiners are commonly supposed to denote partial, trivial choice functions, defined only on singleton sets. The 'the' of 'the hat', for instance, is the function in (1). If there is one hat, ⟦the hat⟧ refers to it; otherwise the computation is ill-defined. In this paper I argue that this is an illusion, that really *two* things happen every time 'the' occurs felicitously in a sentence, and it is only when they happen in immediate succession that the computation reduces to the partial function defined above.

(1) $\lambda P.\begin{cases} x & \textbf{if } P = \{x\} \\ \# & \textbf{otherwise} \end{cases}$

First, ⟦the⟧ introduces a discourse referent satisfying the descriptive content of its nominal complement. It allocates an address in the discourse state and reserves that address for a hat, say. The number of potential updates to any given initial state will be equal to the number of ways of instantiating that new address with a particular (relevant) hat. This part of the definite determiner's meaning is equivalent to a dynamic semantic *in*definite determiner, like 'a'. But then, over and above this referent-introduction, it inspects the set of potential outputs, checking whether there is any lingering uncertainty as to the value of the newly allocated discourse referent. If all of the outputs indeed assign the designated variable to the same entity, then all is well and the computation proceeds. But if there are multiple candidates for that variable across the various potential outputs of the update, the computation crashes. Figure 1 schematizes this configuration.

Figure 1 Schematic depiction of bipartite semantics for the definite determiner

$$\lambda g.\begin{cases} G & \textbf{if } |G_v| = 1 \\ \emptyset & \textbf{otherwise} \end{cases}, \text{ where } G = \{g^{v\mapsto x} \mid \mathsf{hat}\,x\}$$

$\mathbf{1}_v$ $\quad \lambda g.\,\{g^{v\mapsto x} \mid \mathsf{hat}\,x\}$

$\textbf{the}_v$

$\textbf{some}_v$ $\quad$ hat

The reason for supposing that definiteness consists in these two independent sub-processes is that occasionally, I will argue, things happen between the first operation and the second. Consider the example in (2). Haddock (1987) observed that this expression could well be felicitous in a context with multiple salient, relevant hats, so long as only one of them contains a rabbit. Likewise, there could be plenty of rabbits in the scene as long as there's a single rabbit in that unique rabbit-containing hat.

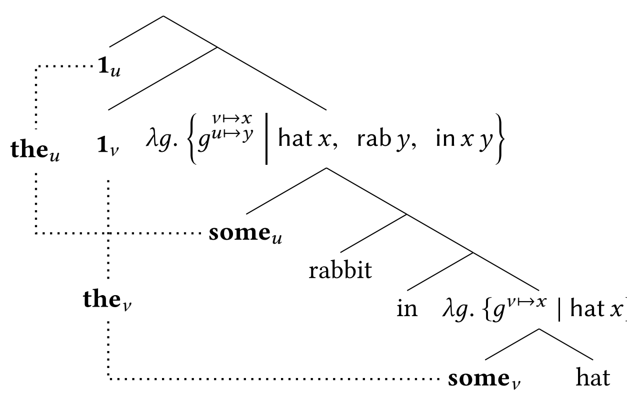
(2) the rabbit in the hat

  a. [the rabbit in u]$_v$ where u is the hat that v is in
  $\approx$ 'the rabbit in the hat that has a rabbit in it'

At first glance, (2) appears to present a kind of nested Bach-Peters paradox, something along the lines of (2a). But I will show that this sort of apparent mutual definedness is just what happens when the cardinality-testing component of the inner definite is enforced between the existential and uniqueness components of the outer definite. In other words, it is a situation in which the two semantic processes are interleaved rather than nested.

In a nutshell, the compositional computation of (2) unfolds as follows, depicted in the quasi-LF of Figure 2. Given any input g, the inner article introduces a referent v and generates a set of outputs, one for each way of mapping v to a salient hat. Composition proceeds through the prepositional phrase and nominal adjunction, accumulating further constraints on the value assigned to v. When the outer article combines with this dynamic restrictor, it introduces another referent u. The result of this introduction is a new set of outputs, each of which extends an output from the restrictor by mapping u to some rabbit in whatever that output assigned to v. It is at this point, after both articles have updated the context with potential witnesses for these variables that the uniqueness tests are enforced. First the inner definite presupposes that all outputs agree on the value of v. Crucially, all of the remaining candidate assignments at this point map v to a *rabbit-containing* hat. The cardinality test guarantees that there is only one such entity of relevance. Then the outer definite presupposes unicity in the value of u, ensuring the presence of exactly one rabbit in that one hat with rabbits in it.

Figure 2 Schematic depiction of interleaved definiteness of (2)



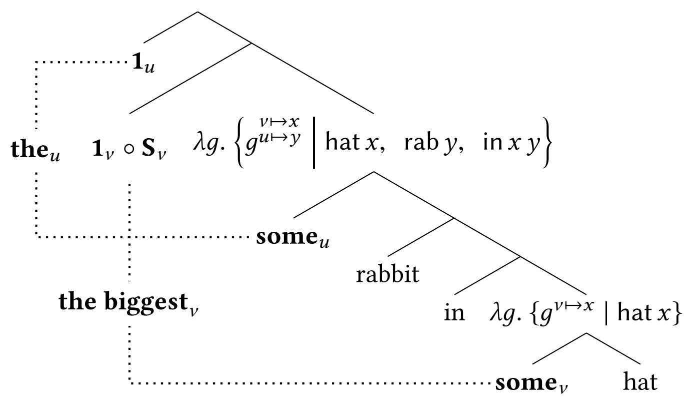
The key to this analysis is that assignment functions (or any analogous notions of dynamic state) are by their nature expected to satisfy all predicative constraints in view *simultaneously*. For instance, if we consider the denotation of 'he$_u$ likes her$v$' not as a function from assignments to truth values, but as the characteristic set of that function, then it will include only assignments that map u to a male and v to a female *that u likes*. Of course dynamic frameworks often take this notion of a denotation as a set of assignments very literally, and in general the set of outputs at any given point in a semantic derivation will include only those assignments that map referent variables to entities in accordance with the predicates that relate them. This is the sense in which the discourse referents u and v mutually define each other.

Even more dramatically, superlative adjectives may also take semantic action between the existential and cardinal operations of a definite article, leading to what are commonly called *relative readings*. The description in (3), for instance, may be felicitous even if the biggest relevant hat in the context has no rabbits in it, or even if there are several equally-sized hats all larger than any others (and thus no "biggest hat"), as long as one of the rabbits is in a bigger hat than any of the others. Thus the superlative is understood to quantify not over hats *simpliciter*, but over hats containing rabbits.

(3) the rabbit in the biggest hat

a. [the rabbit in x]$_y$, where x is a hat bigger than any hat containing a rabbit not equal to y
≈ 'the rabbit in the biggest hat that has a rabbit in it'

Figure 3 Schematic depiction of interleaved definiteness of (2)



The meaning of this description is computed exactly as in Figure 2, except that the maximality test encoded in the superlative also shoots the gap between the outer determiner's definite and indefinite components (see Figure 3). I assume the superlative denotes a filter on outputs, roughly of the form $\lambda G.\,\{g \in G \mid \neg\exists g' \in G.\, g'\,v > g\,v\}$, where v indexes the referent introduced by the superlative's DP. The outputs generated by the nominal complement are the same as they are for the interesting reading of (2). So filtering out all but the v-maximal assignments in this set amounts to keeping only those assignments that map v to a *rabbit-containing* hat at least as large as any other *rabbit-containing* hat (and u to a rabbit in that hat). Finally the uniqueness test of the outer definite guarantees that all of the biggest such hats are inhabited by the same rabbit, i.e., that there is a single rabbit winner of the biggest-hat inhabiting contest.

As far as I am aware, this paper is the first to connect Haddock descriptions and relative superlatives. In the service of drawing that connection out, Section 2 lays out a handful of the interesting semantic properties that relative superlatives are known to exhibit, and establishes that Haddock readings display the same telltale behaviors. Section 3 steps through the analysis sketched above in more detail, primarily with an eye toward demonstrating how the parallel mechanics of the phenomena work, and how they derive appropriate felicity conditions on reference. One important corollary of this connection is that a lot of the semantic technology often attributed to the superlative morpheme itself is absorbed into the semantics of the definite article. This, I'll argue, explains the role of the determiner in licensing relative readings, which is a sore spot for many analysis of superlatives (most notably, Heim 1999 and its derivatives).

This is also the first analysis to treat superlatives as filters on outputs, or dynamic tests. In so doing, it connects superlatives (and definites) to recent dynamic approaches to bare and modified numerals. Brasoveanu 2012 in particular has argued for bipartite denotations of DPs like 'exactly five boys', denotations which behave locally like dynamic indefinites but impose "delayed" restrictions on what output contexts can look like. The analysis here then is interesting both in that it forges a theoretical link between between definite determiners and other cardinality-testing determiners, and in that it re-engineers the notion of a delayed test, or *postsupposition*, in terms of split scope.

Finally, there are conceptual correspondences between this split-scope approach to definiteness and recent ideas stemming from the work in Coppock & Beaver 2015. As here, Coppock & Beaver break the process of definite interpretation into two steps. Definite determiners themselves, they contend, return indeterminate denotations, sets of individuals. Determinate individuals are then secondarily extracted from those denotations by an independent type-shifter ι. To some extent, the fragment here is a concrete dynamicization of this sort of process, but there are also important differences between their analysis and this one, especially regarding the timing and scope of uniqueness testing.

All of these formal and conceptual connections are taken up in Section 4. And Appendix A provides the officially reference fragment for deriving the core data points of the paper.

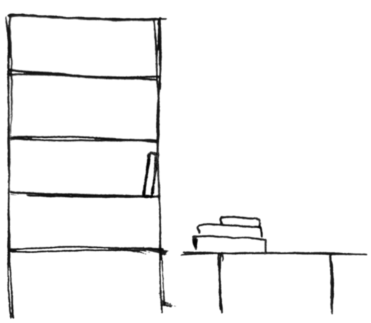
2 Data

In this section, I characterize several of the empirical patterns that separate superlative descriptions from the general class of definite descriptions, highlighting along the way parallels between superlative descriptions and the Haddock phenomenon. All discussion of the theoretical importance of these particular data points is deferred to Section 4. However, a preemptive confession: I am going to concentrate exclusively on superlatives in relative clauses. This brings the connection between relative superlatives and Haddock descriptions into sharp relief, and it allows me to abstract away from the details of focus semantics, question semantics, and the other sources of semantic indeterminacy that relative superlatives are known to feed on. I believe that the analysis here can be extended to those sorts of cases, but it is admittedly somewhat involved (see Bumford 2016).

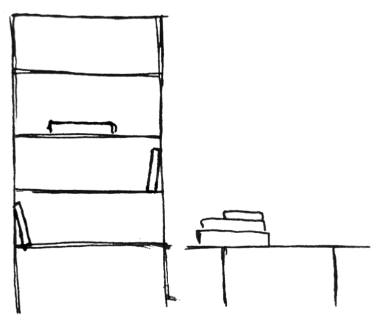
2.1 Essential empirical pattern

The scenes in Figure 4 depict several snapshots of a bookshelf in the process of being loaded up with books. The sentences 4a, 4b, and 4c are all true of their particular stages of the event, despite containing expressions that, taken at face value, might be expected to be undefined. Given that there are four equally salient shelves in each figure, the phrase 'the shelf' in 4a should be infelicitous. Likewise, 'the three shelves' in 4c should fail to isolate any particular triple of shelves from the four options. In contrast, 'the highest shelf' in 4b is well-defined, as there is a single shelf higher than all the others, but it does not contain any books, so the entire object DP of 4b should be meaningless.

(a) I've read the book on the shelf.



(b) I've read the book on the highest shelf.



(c) I've read the seven books on the three shelves.

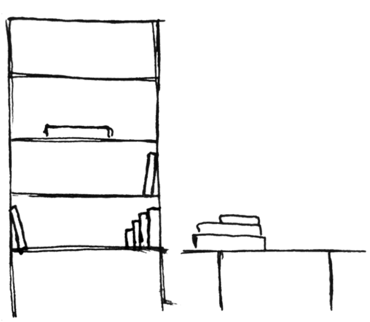


Figure 4 Relative readings of various definite descriptions. In each of (a), (b), and (c), the inner description is additionally restricted to those shelves *that contain books.*

Yet these sentences are all perfectly natural and interpretable, most compositional theories of definite reference notwithstanding. This is because, intuitively, the embedded DPs of Figure 4 do not presuppose the existence of any unique (highest) shelf or set of three shelves in the scene. Instead, they target the (highest) shelf/shelves *on which there are books.* For instance, what 4a seems to mean is not that I've read the book on the one true shelf in the picture, but rather that I've read the book on the shelf that has a book on it. Similarly, 4b doesn't require anything of the very highest shelf in the bookcase, the one with the picture on it; it just requires that the highest shelf with a book be such that the book on it, I've read. And then again with 4c. All that the object of the sentence commits to is the existence of exactly three book-supporting shelves, containing in total seven shelved books.

Following the literature on superlatives, from which this phenomenon is most well-studied, I will call interpretations like these *relative readings* of the embedded DPs. Descriptively speaking, what the readings have in common is that the quantificational force of the determiner (and adjective) is restricted to those elements that — in addition to satisfying the property denoted by the nominal — stand in some relation to other objects in the scene, where the appropriate relation is determined by the syntactic context of the phrase.

In the following subsections I will try and flesh out the parallel here by showing that a number of the interesting behavioral properties of relative superlatives are mirrored by relative definites.

2.2 Definiteness effects

Szabolcsi (1986) identified a battery of syntactic environments that are tolerant of relative superlatives despite being generally hostile to definite descriptions. One such environment is the object of so-called *relational 'have'*. For example, the definite variant of (4a) is ungrammatical, though the indefinite variant is perfectly fine. In the same context, the morphologically definite relative superlative 'the meanest sister' is felicitous; (4b) describes the student whose sister is meaner than any other student's sister. Perhaps surprisingly, (4c) is also felicitous if it is known that there is exactly one student-sister pair $\langle x, y\rangle$ of which y is mean. Notice that this presupposition is stronger than what would be expected if the object were, for whatever reason, interpreted merely existentially. That is, (4d) might well describe Cinderella, once she finally got down to finishing that PhD, but not (4c).

(4) a. Do any students here have {a, *the} mean sister?
   b. the student who has the meanest sister
   c. the student who has the mean sister
   d. the student who has a mean sister

It is also worth observing in this respect that familiarity with the mean sister's existence is not sufficient for the restrictions of relational 'have'. Consider (5) in this regard. The object of the second clause is familiar — anaphoric, in fact — but the sentence is nevertheless deviant.

(5) *John has a mean friend, and his sister has the mean friend too

Another definite-averse environment that supports relative superlative descriptions is the pivot of the existential 'there' construction. The question in (6a) illustrates this. Even if it is known that there was only one (relevant) battle in Louisiana, the definite variant of (6a) is quite marked. In contrast, the superlative description in (6b) is entirely natural; it characterizes the battle that is the subject of more movies than any other battle. Again surprisingly, the description in (6c) is also well-formed if indeed there's exactly one (relevant) movie y about x, where x is the unique (relevant) battle that y is about. Once more the presupposition here represents the *joint* definiteness of the two nominals, linked by the about relation. It is more demanding than the presupposition of (6d), say, which requires only that there be a unique battle featured in *at least one* movie, possibly in several.

(6) a. When was there {a, *the} battle in Louisiana?
b. the battle that there are the most movies about
c. the battle that there's the movie about
d. the battle that there's a movie about

2.3 Intensional environments

Another important data point in the superlative literature comes from constructions of the form in (7a) (see Heim 1985, 1999 for original discussion). There are many things this description could be taken to mean. The meaning of interest for the study of superlatives is the one in which (7a) describes John, when John needs a 50 inch shovel, Fred a 40 inch shovel, and Bill a 30 inch shovel, but none of them have any particular shovels in mind, except for those respective size specifications. The reason this interpretation is interesting is that the there does not appear to be any unicity or familiarity associated with the intensional object; the boys will be satisfied with *any* appropriately-sized shovels. Instead what the superlative targets is something like the boys' respective shovel-needs, where the size of each boys need is measured by the size of shovel that he's after.

Interestingly, the description in (7b) may also be well-formed even when there is no particular shovel under discussion, or even any shovel that any boy has his eye on. For instance, (7b) could describe John if it is known that John needs a shovel, Bill needs an hammer, and Fred needs a drill. It would still be felicitous if Mary needed a shovel as well as John, so long as Mary is not a boy.

(7) a. the boy who needs the biggest shovel
b. the boy who needs the shovel

One potential explanation for the unexpected felicity of (7b) is that the intensional object is genuinely definite, but subordinated to the known modal context in which John needs a shovel. The text in (8) illustrates the possibility of this. Here it is perfectly coherent to maintain that the description in the second clause is definite though its unicity is relative to the world (and perhaps binding index) in which it is evaluated.

(8) John wants a shovel, and he wants the shovel to be big

But as established in the previous subsection, anaphoric descriptions are no better than other determinate DPs in the object of relational 'have'. This is true for modally-subordinated anaphoric descriptions as well, as evidenced by the ungrammaticality of (9).

(9) *John wants to have a friend, and he wants his sister to have the friend too

Nevertheless, (10a) is felicitous in the same sort of context as (7b): if John wants a little brother while Fred and Bill want sisters, then (10a) refers to John. Other examples are given in (10b) – (10d).[1] This means that the acceptability of the embedded description cannot simply be a matter of subordinated definiteness. My intuition is that much like the superlative in (7a), whatever uniqueness is imposed by the second definite in (7b), it seems to have less to do with shovels (in this world or any other) and more to do with *shovel-needs*. That is, (7b) characterizes the boy *whose unique (relevant) need* is for a shovel.

1. The γ diacritic marks naturally-occurring examples

(10) a. the boy who wants to have the little brother

b. the girl who wants to have the gold tooth

c. $^{\gamma}$ A gestational surrogate has no genetic link to the couple that wants to have the child

d. $^{\gamma}$ [A]s a result of the prevailing Hong Kong law, more than 90 percent of sperm and egg donors are known to the couple that wants to have the baby.

2.4 Scope islands

A number of researchers have contributed judgments of island boundaries for relative superlative readings (e.g., Szabolcsi 1986, Farkas & Kiss 2000, Chacón & Wellwood 2012). The expression in (11a) can only refer to the doctor who knows which treatment has the following property: it cured more patients than any other treatment. It cannot refer to the doctor that maximizes the following function: $\lambda xn.\, x$ knows which treatment cured at least n patients. This latter description would refer to John if, for example, John knows which treatment cured 10 patients, Mary knows which patient cured 8 patients, and Bill knows which cured 4 patients. Nor can the description in (12a) refer to Referee Mary just in light of John's having insulted her after a 30 minute game, Bill after a 20 minute game, and Sue after a 10 minute game.

(11) a. # the doctor who knows which treatment cured the most patients

b. # the doctor who knows which treatment cured the patient

(12) a. # the referee that John insulted after the longest game

b. # the referee that John insulted after the game

Likewise, the description in (11b) cannot refer to the doctor of the unique doctor-patient pair $\langle x, y\rangle$ such that x knows which treatment cured y. No, for (11b) to make sense, it must already be known who "the patient" is (or there must be enough contextual evidence to figure this out), so that the hearer can work backwards to isolate the relevant doctor. The same goes for (12b); it is undefined except in discourse contexts featuring a single salient game and a single insulted referee.

2.5 Possessive DPs

The final parallel I want to draw attention to is the lack of relative readings for possessive descriptions, both plain and superlative. It has occasionally been observed that superlatives in DPs with prenominal possessors strongly resist relative readings (Schwarz 2005: p. 200, Bos 2009: Section 4.1). The example in (13a), for instance, can only be understood to describe the student who read *Hamlet*, not the student who chose to read a longer play than any of the others. This absence stands in rather striking relief to the expression in (13b), which are ambiguous in the now familiar way. The only investigation that I have been able to find into this intriguing contrast comes from unpublished work by Chacón & Wellwood (2012). They point out that quasi-possessive double genitive descriptions like (13c) are compatible with relative interpretations. They further establish that this contrast is robust across English, Japanese, Spanish, and Russian.

(13) a. # the student who read Shakespeare's longest play

b. the student who read the longest Shakespeare play

c. the student who read the longest play of Shakespeare's

Prenominal possessors also resist Haddock readings. Compare (14a) and (14b). The latter may describe a student who chose as the subject matter for her assignment a play by Shakespeare (any play), assuming that student is the only one to have done so. The former cannot. It presupposes a unique play associated with Shakespeare, and described the student who read that play.

(14) a. # the student who read Shakespeare's play

b. the student who read the Shakespeare play

This is especially puzzling in light of the fact that possessive DPs are generally *more* receptive to indeterminate interpretations than plain definite DPs (Partee & Borschev 2001, Barker 2011, Coppock & Beaver 2015). For instance, (15a) asserts that *Edward II* should be counted among Marlowe's works, rather than those of Shakespeare; which is to say, it is one of Marlowe's plays, rather than one of Shakespeare's. The sentence in (15b), however, identifies *Edward II* as the unique play associated with Marlowe, not to be confused with whatever is the unique play associated with Shakespeare.

(15) a. *Edward II* is Marlowe's play, not Shakespeare's

b. # *Edward II* is the play by Marlowe, not the play by Shakespeare

Thus it appears that even though possessive DPs sometimes admit of indeterminate interpretations, they do not participate in relative readings. Definite DPs on the other hand do not readily shed their definiteness requirements, but do submit to ready relativization.

2.6 Summary of data

The brief presentation of data in this chapter has attempted to bolster the hypothesis that relative readings of superlatives and definites are reflexes of the same semantic mechanism. Both kinds of definite descriptions are felicitous in existential and relational 'have' constructions, both can have locally indeterminate force in intensional environments, both are subject to locality effects like the scope islands introduced by tensed clauses and adjuncts. Furthermore, relative readings were shown to depend on the definite determiner, in that they were unavailable to nearly identical variants with possessive rather than definite descriptions. In the next section I spell out the vision of this paper for what that common mechanism of relative readings might be.

3 Analysis

3.1 Core proposal

At the heart of the fragment I will propose is a compositional dynamic semantics in the style of, e.g., Groenendijk & Stokhof 1991, Muskens 1996, Brasoveanu 2007. The definite article interacts with the dynamics in two ways. Like an indefinite, 'the' nondeterministically allocates a discourse referent to some variable of its input context. Then like a numeral (or negation, or quantifier, or modal), it tests that across its output contexts the entity assigned to that variable is determinate; i.e., that all outputs agree on the value of that variable. Moreover, just as 'the' tests for consistency across outputs, superlatives may test outputs for maximality with respect to some ordering. For instance, 'biggest' will pit outputs against one another with respect to the size of the value they assign to some index, filtering out all but the maximal such assignments.

Crucially, the introduction of the discourse referent and the evaluation of uniqueness across the potential assignments of values to that referent may happen at different points in the computation of the sentence. Relative readings of superlatives emerge when properties imposed by intervening lexical material constrain the set of assignments that the superlative compares.

3.2 Haddock readings, singular and plural

The derivation in (16) depicts the manner in which simple, isolated definite descriptions compose. The indefinite component '$\mathbf{some}_v$' combines with the restrictor 'book' to produce a standard sort of dynamic indefinite update. Given an input assignment, it returns a set of ⟨individual, output-assignment⟩ pairs, one for each entity in the domain satisfying the predicate book. This set of outputs is then tested for global uniqueness. $\mathbf{1}_v$ is an abbreviation for the identity function, *if* the update m it inspects is constant across its assignments for the discourse referent v (at some input g). Otherwise, it throws a wrench in the compositional gears by returning the degenerate update $\lambda g.\,\emptyset$. That is, $\mathbf{1}_v \coloneqq \lambda mg.\begin{cases} G & \textbf{if } |G_v| = 1 \\ \emptyset & \textbf{otherwise} \end{cases}$, where $G = m\,g$, and $G_v \coloneqq \{h\,v \mid \langle\cdot, h\rangle \in G\}$.[2]

(16) the book

$$\lambda g.\begin{cases} G & \textbf{if } |G_v| = 1 \\ \emptyset & \textbf{otherwise} \end{cases}, \text{ where } G = \{\langle x, g^{v\mapsto x}\rangle \mid \text{book}\,x\}$$

$$\mathbf{1}_v \qquad \lambda g.\,\{\langle x, g^{v\mapsto x}\rangle \mid \text{book}\,x\}$$

$$\mathbf{some}_v \qquad \text{book}$$

Since the indefinite generates a distinct output for every book in the relevant contextual domain, $\mathbf{1}_v$ will fail unless the set of books in the domain is a singleton set, i.e., unless there's a unique salient book. This guarantees that in this simple case $[\![\text{the book}]\!] = \lambda g.\,\{\langle x, g^{v\mapsto x}\rangle \mid x = \iota\,\text{book}\}$, assuming the $\mathbf{1}_v$ test is passed. Essentially, the description denotes the determinate update that assigns v to the unique relevant book in the context.

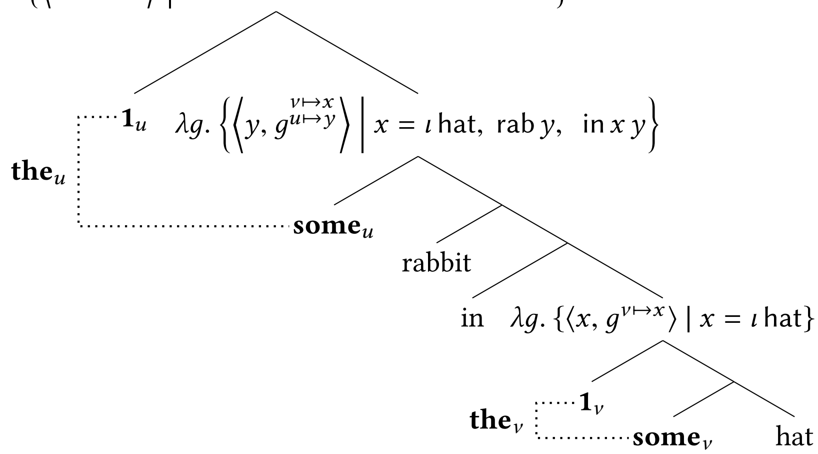
Things get more interesting in the Haddock-style cases, where one definite is nested within another. Such descriptions are in principle ambiguous between *absolute* and *relative* readings. Example (17) diagrams what I take to be the source of the ambiguity. For simplicity I only provide the denotations of nodes that illustrate the semantic action of the determiners, omitting details about composition (see Appendix A for the full, explicit fragment). Also from here on out, I will write the denotations assuming that uniqueness tests are passed.

First, consider the absolute reading of (17), depicted in (17a). The uniqueness tests associated with both definite determiners are enforced immediately after their respective discourse referents are introduced. As in (16), this has the expected effect of crashing the computation unless the two syntactic complements — 'hat' and 'rabbit in the hat' — denote singleton sets. In a little more detail, the denotation of the inner definite node is exactly as in (16). If it succeeds, it will be the deterministic update from an input g to the single output $g^{v\mapsto x}$, where x is the unique salient hat in the context. The outer *in*definite then pairs each rabbit x together with an output that remaps the variable u to that rabbit. Finally, the outer uniqueness test ensures that this set too is a singleton, and thus that there is exactly one such rabbit in x.

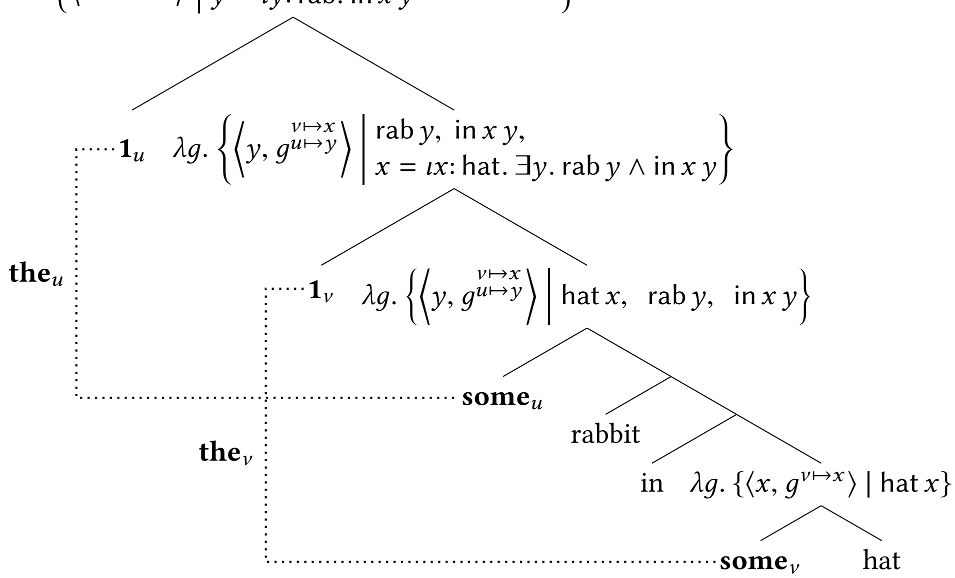
2. I will use '$\cdot$' as a sort of wildcard pattern; in the comprehension of a set, it can be bound to any entity that is not referred to elsewhere and whose name thus doesn't matter. The notation $\{h\,v \mid \langle\cdot, h\rangle \in G\}$, for instance, is equivalent to $\{h\,v \mid \exists\alpha.\,\langle\alpha, h\rangle \in G\}$.

(17) the rabbit in the hat

a. $\lambda g.\left\{\left\langle y, g^{\substack{v\mapsto x\\ u\mapsto y}}\right\rangle \,\middle|\, x = \iota\,\mathsf{hat},\quad y = \iota y.\ \mathsf{rab}\ y \wedge \mathsf{in}\ x\ y\right\}$ [Absolute]



b. $\lambda g.\left\{\left\langle y, g^{\substack{v\mapsto x\\ u\mapsto y}}\right\rangle \,\middle|\, \begin{array}{l} x = \iota x\colon \mathsf{hat}.\ \exists y.\ \mathsf{rab}\ y \wedge \mathsf{in}\ x\ y, \\ y = \iota y\colon \mathsf{rab}.\ \mathsf{in}\ x\ y \end{array}\right\}$ [Relative]



In contrast, the relative reading of (17) is depicted in (17b). In this configuration, the numerosity test of the inner determiner actually splits the scope of the outer determiner's indefinite and numerosity requirements. Composition up to these tests proceeds as if the two definite determiners were in fact standard, discourse-referent-introducing indefinite determiners. This now is the crux of the analysis, and the reason to insist on dynamic entries for the determiners: each output assignment at this node isolates a portion of the model simultaneously satisfying the constraints $\mathsf{hat}\ x$, $\mathsf{rabbit}\ y$, and $\mathsf{in}\ x\ y$. So the complement of the first test, $\mathbf{1}_v$, is the function that sends an assignment g to the set of outputs $g^{\substack{v\mapsto x\\ u\mapsto y}}$ where x is some hat, and y is some rabbit *in that hat*.[3]

As a result, checking that each of these outputs agrees on the value of v is tantamount to checking that there is exactly one *rabbit-containing hat.* Subsequently, checking that each of these outputs agrees on the

3. One more note on notation. Variables bound by quantifiers and lambdas are sometimes formally restricted, so that $\iota y\colon \mathsf{rab}.\ \mathsf{in}\ x\ y$ is equivalent to $\iota y.\ \mathsf{rab}\ y \wedge \mathsf{in}\ x\ y$; and $\forall y\colon \mathsf{rab}.\ \mathsf{in}\ x\ y$ equivalent to $\forall y.\ \mathsf{rab}\ y \Rightarrow \mathsf{in}\ x\ y$; etc.

value of u is tantamount to checking that this unique enrabbitted hat is inhabited by a single rabbit. The net effect is then equivalent to checking that there is a single pair $\langle x, y\rangle$ such that x is a hat, y is a rabbit, and y is in x, which is exactly the felicity condition of the whole complex description.

In this fashion we achieve the kind of polyadic definiteness that DPs of this form seem to evoke without giving up any of the normal principles of compositionality. The two definite determiners mean what they always mean; they both contribute discourse referents, and they both ensure that their referents are uniquely instantiable within the model. The only thing that is unusual about these constructions, from the standpoint of the current proposal, is that those pieces take scope over different subportions of their syntactic contexts, so that their effects are interleaved rather than nested.

This technique extends immediately to other sorts of relative readings. The simplest such examples are just the plural variants of Haddock cases, as outlined in (19) below. The first step is generalizing the definite determiner to test for maximality rather than uniqueness. The plural DP 'the tables' should generate a discourse referent pointing toward the complete set of salient, relevant tables, rather than any arbitrary subset of them. Fortunately, since the size-checking component of 'the' already looks at the entire set of potential outputs — thereby effectively inspecting the entire range of possible legitimate values for the discourse referent it is tied to — it is straightforward to formulate a *max* operator in the vein of our uniqueness test: $\mathbf{M}_v := \lambda mg.\, \{\langle \alpha, h\rangle \in m\, g \mid \neg\exists\langle \beta, h'\rangle \in m\, g.\, h\, u \sqsubset h'\, u\}$.

(18) the tables

$$\lambda g.\, \{\langle X, g^{v\mapsto X}\rangle \mid \textsf{tables}\, X,\;\; \neg\exists Y\colon \textsf{tables}.\, X \sqsubset Y\}$$

$$\mathbf{M}_v \quad \lambda g.\, \{\langle X, g^{v\mapsto X}\rangle \mid \textsf{tables}\, X\}$$

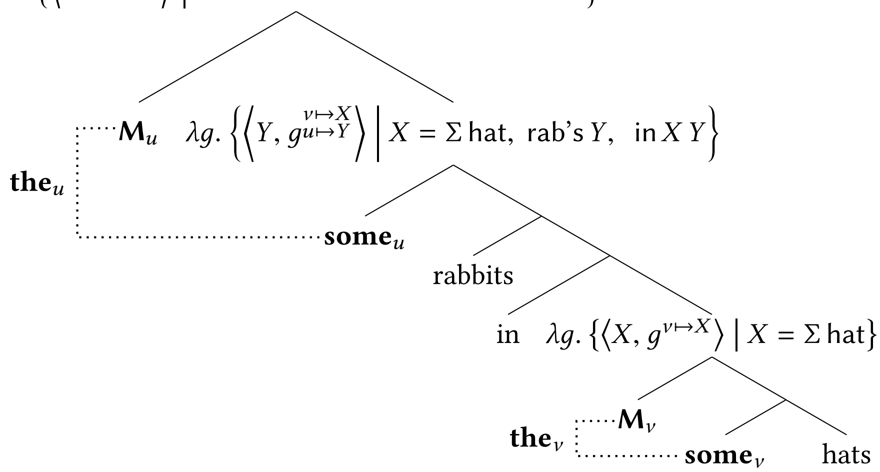
$$\textbf{some}_v \quad \text{tables}$$

The indefinite generates a variable that ranges over sums of tables. At an input g, the max operator looks at all of the outputs h that remap v to one of those sums, and throws away any such outputs that aren't "maximal" sums. That is, it keeps only those outputs that assign v to an individual that is not a subpart of any individual assigned to v by another assignment. In this simple case, given that the indefinite will generate one output for every possible sum of (relevant) tables, ⟦the tables⟧ will be equivalent to $\lambda g.\, \{\langle X, g^{v\mapsto X}\rangle \mid X = \Sigma\, \textsf{table}\}$, where Σ is the generalized mereological fusion operator over individuals.

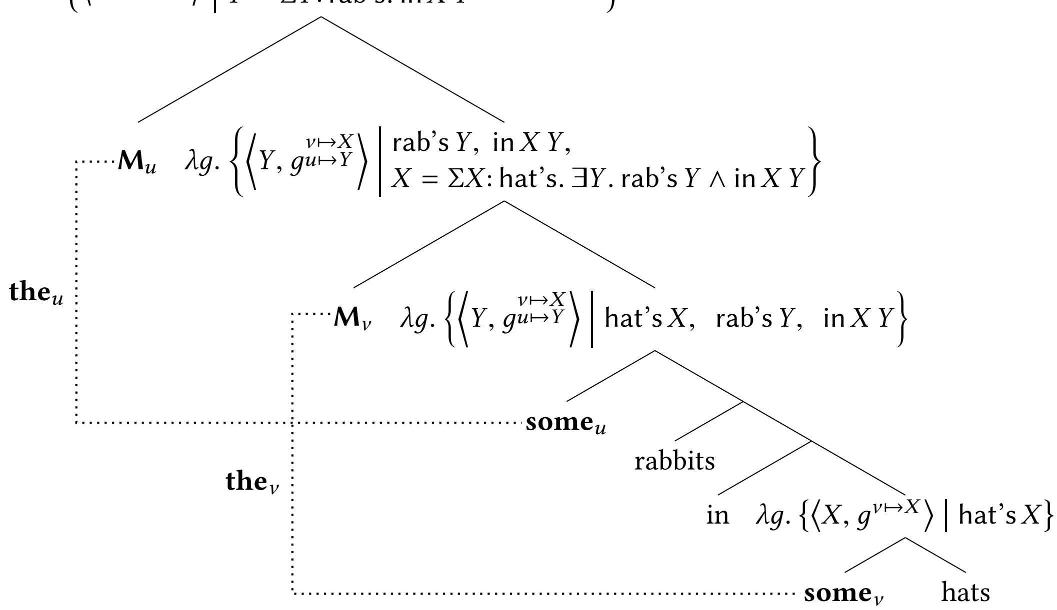
In (19) then are the plural constructions analogous to those in (17). On the absolute reading (19a), the inner description immediately maximizes over its dref, loading the complete set of relevant hats X into the variable v. The outer indefinite then generates, for each sum of rabbits Y that are in X, an output assignment mapping u to Y. I assume that relations are interpreted cumulatively (e.g., Beck & Sauerland 2000), so that $\textsf{in}\, X\, Y$ will only be true if every $y \sqsubseteq Y$ is in some $x \sqsubseteq X$ and every $x \sqsubseteq X$ has some $y \sqsubseteq Y$ in it. What the outer indefinite ranges over, then, is the set of rabbit-sums each part of which is in at least one hat and which cumulatively inhabit the entire set of hats. Finally the outer max operator discards all but the largest such sum of rabbits. This guarantees that the entire phrase is interpreted deterministically: the only individual in its denotation is the set of *all* those rabbits that are (cumulatively) in *all* of the hats. If there is no such rabbit-sum — because, e.g., one of the hats is rabbitless — then the denotation fails to refer.

(19) the rabbits in the hats

a. $\lambda g.\left\{\left\langle Y, g^{\substack{v\mapsto X\\u\mapsto Y}}\right\rangle \,\middle|\, X = \Sigma\,\mathsf{hat},\;\; Y = \Sigma Y\colon \mathsf{rab's.\ in}\, X\, Y\right\}$ [Absolute]



b. $\lambda g.\left\{\left\langle Y, g^{\substack{v\mapsto X\\u\mapsto Y}}\right\rangle \,\middle|\, \begin{array}{l} X = \Sigma X\colon \mathsf{hat's.}\ \exists Y\colon \mathsf{rab's.\ in}\, X\, Y,\\ Y = \Sigma Y\colon \mathsf{rab's.\ in}\, X\, Y \end{array}\right\}$ [Relative]



The first several steps of the relative reading (19b), up to the maximality test $\mathbf{M}_v$, are exactly as in (17b), except that the drefs u and v are mapped to sums of rabbits and hats, respectively. So just before the first maximality filter, the set of outputs includes all possible assignments that pair a sum of rabbits Y — stored at u — with a sum of containing hats X — stored at v. This again is the crucial bit that the dynamic framework buys us; as we build out the denotation of the phrase, we keep only those slices of the world that satisfy the constraints imposed by predicates and relations on discourse referents. So when it comes time to check for cardinality and/or comparative maximality of certain variables, we are comparing only live candidates for those values. In this case, that means that when we maximize over v, we compare only rabbit-holding hats.

The actual maximization then filters out any assignments that choose a dominated sum of such hats, that is, a sum of hats that is a proper subpart of some other sum of hats. Because the property of (cumulatively) containing a sum of rabbits is, well, cumulative, there is guaranteed to be exactly one such undominated hat sum. So after $\mathbf{M}_v$, the set of outputs contains only those assignments that send v to X, the top of the hats-that-have-rabbits-in-them lattice, and u to a sum of rabbits in X. Then at $\mathbf{M}_u$, we perform a similar maximization, this time over the set of rabbit-sums that are in X. Again, since the property of being a rabbit-sum in X is cumulative, we're guaranteed to end up with a single remaining choice for u, namely Y, the largest possible collection of rabbits in the largest possible collection of rabbit-containing hats. On the relative reading here, just as in the singular case (17), there may well be hats that are completely bereft of rabbits; it is of no consequence, since we do not begin filtering/counting until we have learned more about what sort of thing we are looking for.

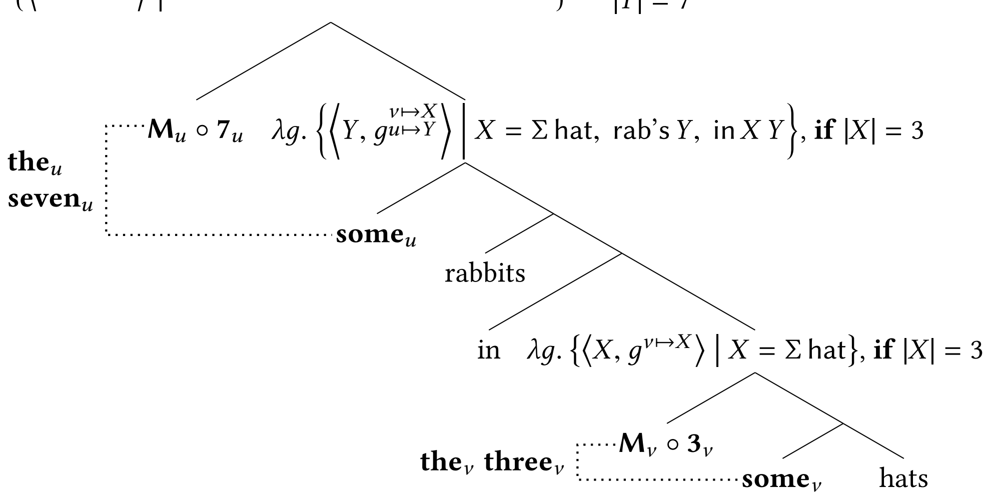
3.3 Numerals

The absolute and relative readings of definite numeral descriptions are structurally identical to those of plain definites and definite plurals, except that the numeral introduces its own cardinality filter, to be executed immediately prior to the maximality test of its hosting definite. For instance, consider the absolute and relative readings of (20), sketched in (20a) and (20b), respectively.

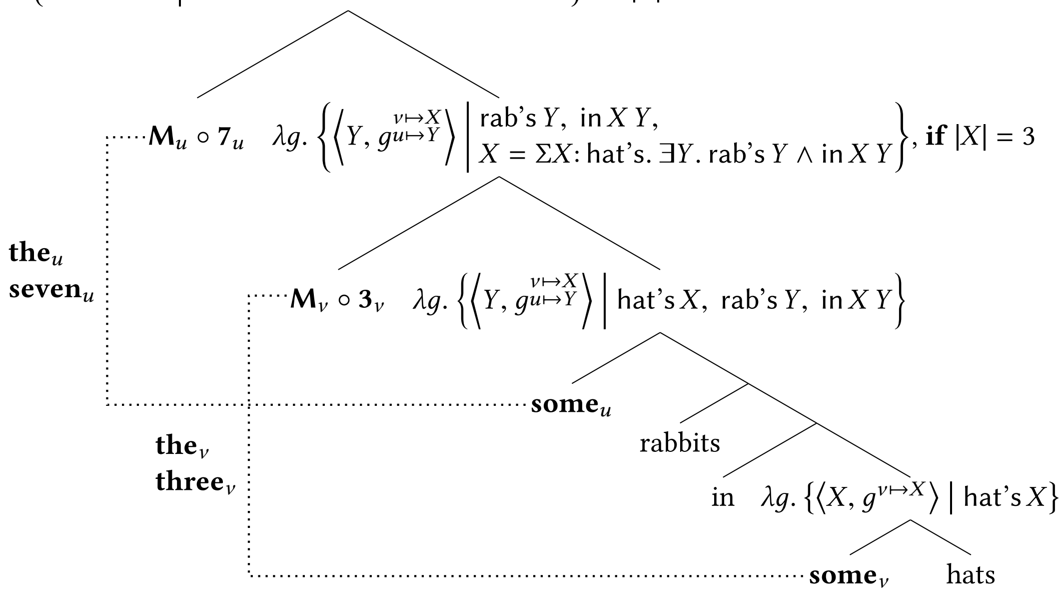
Setting $\mathbf{3}_u$ (resp. $\mathbf{7}_u$) $\coloneqq \lambda m g.\ \begin{cases} G & \textbf{if } \log_2 |G_u| = 3 \text{ (resp. 7)} \\ \emptyset & \textbf{otherwise} \end{cases}$, where $G = m\, g$, the absolute derivation proceeds as usual without much surprise. The inner description serves up all sums of hats in the scene, and then tests that this set of hat-sums was generated from a set with exactly three atoms. If so, it throws away all but the single output that assigns v to the mereological top of this set, the sum of all three hats. Then given this determinate mapping of v, the outer description guarantees in the same fashion the existence of exactly seven rabbits cumulatively located in those three hats.

(20) the seven rabbits in the three hats

a. $\lambda g.\ \left\{\left\langle Y, g^{\substack{v\mapsto X\\ u\mapsto Y}}\right\rangle \,\middle|\, X = \Sigma\,\mathsf{hat},\ Y = \Sigma Y\colon \mathsf{rab's.\ in}\, X\, Y\right\}$, $\textbf{if}\ \begin{matrix}|X| = 3\\ |Y| = 7\end{matrix}$ [Absolute]



b. $\lambda g.\left\{\left\langle Y, g^{\substack{v\mapsto X\\u\mapsto Y}}\right\rangle \;\middle|\; \begin{array}{l} X = \Sigma X\colon \text{hat's}.\ \exists Y\colon \text{rab's}.\ \text{in}\, X\, Y, \\ Y = \Sigma Y\colon \text{rab's}.\ \text{in}\, X\, Y \end{array}\right\}, \textbf{ if } \begin{array}{l} |X| = 3 \\ |Y| = 7 \end{array}$ [Relative]



The relative reading, however, delays the force of the inner cardinality tests until the dynamic composition has weeded out any sums of hats that do not between them contain some set of rabbits; i.e., any hat-sums at least one element of which is rabbitless. Once this more restricted collection of hats has been isolated, the cardinality tests ensure a single trio of such rabbit-containing hats and a single septet of hat-contained rabbits.

3.4 Superlatives

Scaling up to absolute and relative superlatives is now just a matter of generalizing the maximization filter used for plurals. Searching for outputs that assign u to something that is not a proper part of what any other output assigns to u is a bit like searching for the outputs with the "most uncontained" u-values. But *parthood* is just one among many relations that might be used to partially order the outputs. They might just as easily be ordered by height or age or ability to start a campfire without lighter fluid.

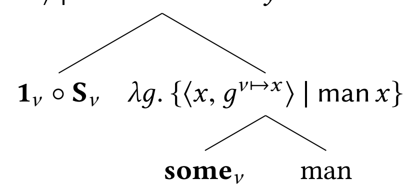
For simplicity, I assume comparative adjectives to denote exactly these sorts of partial orders. For instance, $[\![\text{older}]\!] \coloneqq \lambda yx.\ \text{age}\, x > \text{age}\, y$. Superlative adjectives lift these comparative orders into filters on outputs by excluding any assignments that fail to map the relevant discourse referent to an order-maximal value. Sticking with age, $[\![\text{oldest}_u]\!] \equiv \mathbf{S}_u \coloneqq \lambda mg.\ \{\langle \alpha, h\rangle \in m\, g \mid \neg\exists\langle \beta, h'\rangle \in m\, g.\ [\![\text{older}]\!]\,(h\, u)\,(h'\, u)\}$. And more generally, $[\![\text{-est}_u]\!] \coloneqq \lambda f mg.\ \{\langle \alpha, h\rangle \in m\, g \mid \neg\exists\langle \beta, h'\rangle \in m\, g.\ f\,(h\, u)\,(h'\, u)\}$.

Two remarks in passing about this definition of '-est'. First, as with the comparative, it is degree-free. $[\![\text{older}]\!]$ is simply a relation over individuals, which $[\![\text{oldest}]\!]$ uses to restrict dynamic outputs. This means semantic models for constituents containing these phrases needn't include any degree objects or degree properties (see, among others, Klein 1980, Larson 1988, van Rooij 2011, Djalali 2014 for defenses of this view). Second, the semantic decomposition of $[\![\text{oldest}]\!]$ into $([\![\text{-est}]\!]\,[\![\text{older}]\!])$, rather than $([\![\text{-est}]\!]\,[\![\text{old}]\!])$, respects the cross-linguistic generalization that superlative adjectival forms are morphologically built up from comparative rather than positive forms (Stateva 2002, Bobaljik 2012, Szabolcsi 2012).

With these pieces in place, the analysis of absolute and relative superlative DPs unfolds exactly like that of the absolute and relative plural DPs in (19). To get things started, (21) depicts a basic superlative structure in the vein of (18). As ever, the indefinite supplies a discourse referent that ranges over individuals in the extension of its restrictor. The superlative filter $\mathbf{S}_v$ then throws out any assignments that map v to a man with at least one elder, leaving $\lambda g.\, \{\langle x, g^{v\mapsto x}\rangle \mid \mathsf{hat}\, x,\ \neg\exists y\colon \mathsf{man}.\ \mathsf{older}\, x\, y\}$. Taking this as input, the usual $\mathbf{1}_v$ test supplied by the definite determiner demands uniqueness of this remaining set of elderless men. The whole DP, if it doesn't fail, thus denotes the update that reassigns v to the unique man in the context who is older than all others.

(21) the oldest man

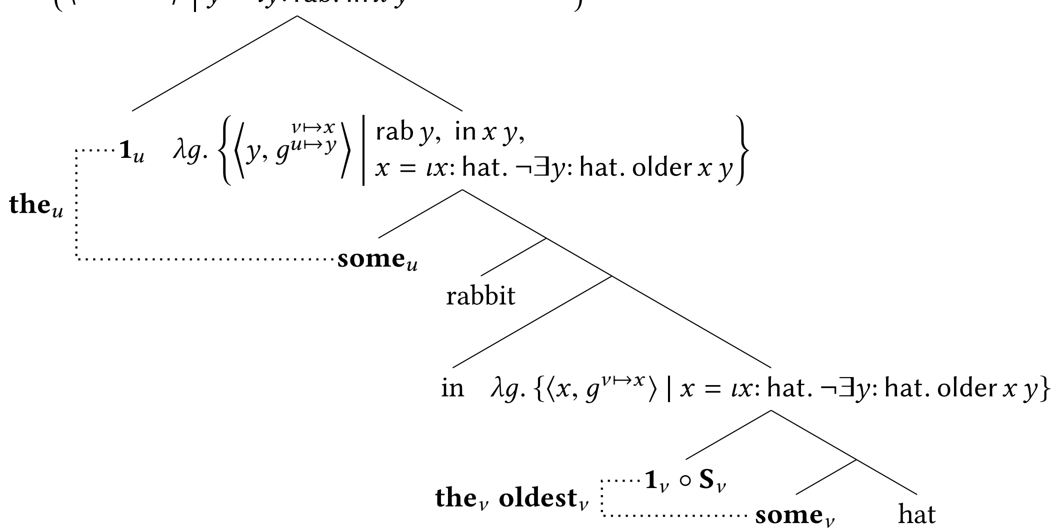
$$\mathbf{1}_v\, (\lambda g.\, \{\langle x, g^{v\mapsto x}\rangle \mid x = \iota x\colon \mathsf{man}.\ \neg\exists y\colon \mathsf{man}.\ \mathsf{older}\, x\, y\})$$



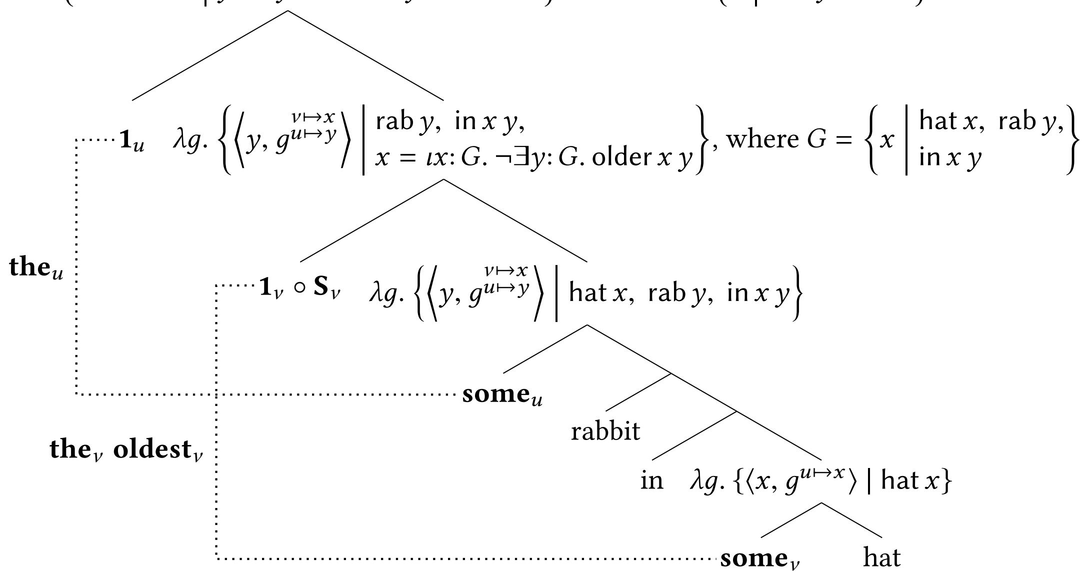
The absolute reading of (22) is by now unsurprising. Assuming uniqueness of the relevant characters is satisfied, it denotes the update that assigns v to the oldest hat, and u to the particular rabbit in it.

(22) the rabbit in the oldest hat

a. $\lambda g.\, \left\{\left\langle y, g^{\substack{v\mapsto x\\ u\mapsto y}}\right\rangle \,\middle|\, \begin{array}{l} x = \iota x\colon \mathsf{hat}.\ \neg\exists y\colon \mathsf{hat}.\ \mathsf{older}\, x\, y, \\ y = \iota y\colon \mathsf{rab}.\ \mathsf{in}\, x\, y \end{array}\right\}$ [Absolute]



b. $\lambda g.\left\{\left\langle y, g^{\substack{v\mapsto x\\u\mapsto y}}\right\rangle \,\middle|\, \begin{array}{l} x = \iota x\colon G.\ \neg\exists y\colon G.\ \mathsf{older}\ x\ y, \\ y = \iota y\colon \mathsf{rab}.\ \mathsf{in}\ x\ y \end{array}\right\}$, where $G = \left\{x \,\middle|\, \begin{array}{l}\mathsf{hat}\ x,\ \mathsf{rab}\ y,\\ \mathsf{in}\ x\ y\end{array}\right\}$ [Rel.]



The relative reading is very much like the relative readings of (17) and (19). Before either the superlative or uniqueness filters are executed, the set of outputs is restricted, solely by the lexical items, to those that map v to a hat and u to a rabbit in it. Only those hats that contain some rabbit or other are up for consideration when the $\mathbf{S}_v$ test goes to work. When that happens, the test discards any outputs that send v to one of these hat that is not as old as some other of these hats. From there, $\mathbf{1}_v$ imposes the restriction that there be a single such unrivaled hat. And subsequently $\mathbf{1}_u$ guarantees that there is a single rabbit in this oldest hat.

4 Discussion and comparison

4.1 The scope vs. restriction superlative debate

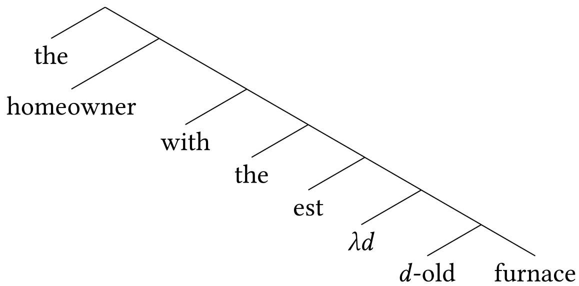
There are two major themes in the semantic literature on superlatives, both with many variations. The first hypothesis, following lines of thought spelled out in Szabolcsi 1986, Heim 1985, and Heim 1999 is that the absolute/relative ambiguity is a traditional semantic scope ambiguity. If the superlative morpheme is interpreted inside its own DP, the meaning is absolute. If however it is interpreted at a position outside of its containing DP, the meaning is relative. Figure 5 provides a minimal fragment illustrating the essential account.

The second hypothesis, also sketched (and rejected) in Heim 1999, developed in Farkas & Kiss 2000 and Sharvit & Stateva 2002, contends that the absolute/relative ambiguity results from pragmatic flexibility in how the quantificational domain of the superlative is restricted. Figure 6 provides a corresponding bare bones fragment with illustrative derivations.

Theories in the mold of Figure 5 that attribute relative readings to the scope of the superlative morpheme suffer from the following well-known peculiarity: in order to generate appropriate truth conditions, it is necessary to assume that the definite article has *indeterminate* semantics (see Szabolcsi 1986 for original discussion of this point and Coppock & Beaver 2014 for recent confirmation). This is all the more surprising in light of the fact that sentences like (23) lack relative readings, to the extent that they are acceptable at all (Herdan & Sharvit 2006). Why the definite article should have merely existential force precisely when the superlative morpheme takes wide scope, is left unexplained by traditional scope-based

Figure 5 Schematic scope-based treatment of abs/rel superlative ambiguity (cf. Szabolcsi 1986, Heim 1999, Bhatt 2002, Hackl 2009, Romero 2013, Sharvit 2015): $[\![\text{est}]\!] = \lambda R x.\, \exists d.\, \{x\} = R\, d$

(a) Absolute reading: 'est' compares furnaces with respect to size.



(b) Relative reading: 'est' compares homeowners with respect to the sizes of their furnace sizes.

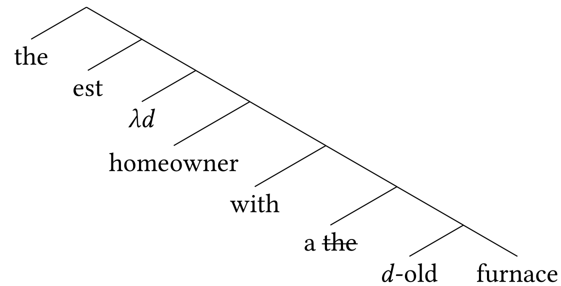
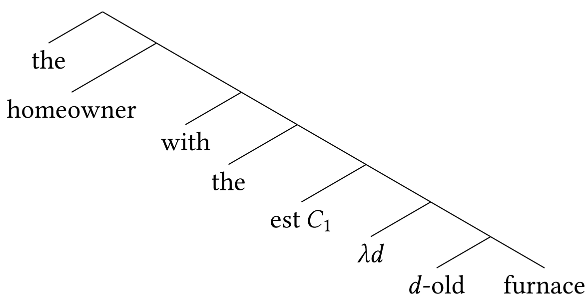
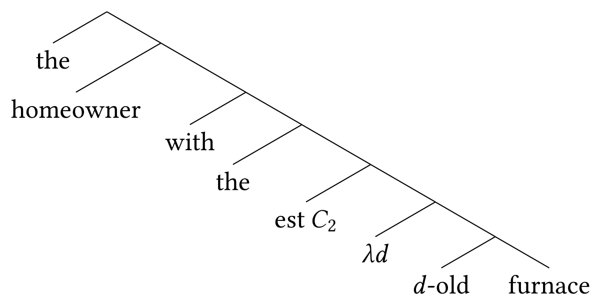


Figure 6 Schematic restrictionist treatment of abs/rel superlative ambiguity (cf. Heim 1999, Farkas & Kiss 2000, Sharvit & Stateva 2002, Herdan & Sharvit 2006, Tomaszewicz 2015): $[\![\text{est}]\!] = \lambda C R x.\, \exists d.\, \{x\} = R\, d \cap C$

(a) Absolute reading: C_1 is the domain of relevant entities.



(b) Relative reading: C_2 is the domain of relevant entities that some homeowner is with.



treatments of superlatives (Heim 1999, Hackl 2009, Romero 2013, Sharvit 2015), as is the absence of relative readings when 'the' is replaced by a determiner that really does have merely existential force.

(23) This year, semantics is the field with a best student
$^{\#}$This year, semantics is the field with a student better than any student in any other field

On the flipside, theories in the mold of Figure 6 that attribute relative readings to covert domain restriction generally suffer from a different peculiarity: they do not generate appropriate truth conditions. The denotations in Figure 6b predict that 'person who climbed the highest mountain' will denote a property true of *any* individual who climbed the highest climbed mountain; it is not offended by ties. This predicts that if John, Mary, and Fred all end up climbing the very same mountain, which turns out to be higher than the one Carl climbs, then it will be true to say that John climbed the highest mountain. In general, as Farkas & Kiss (2000) point out, DPs like the one in (24) do not even seem to be well-formed, though the generic theory in Figure 6 predicts that it should mean that John knows one of the people who climbed as few mountains as anyone.

(24) *John knows a person who climbed the fewest mountains

Even more tellingly, Heim 1999 argues that no choice of individuals C can be used to restrict the superlative description in (25) so that it generates the relative reading characterized below. This is the reading on which (25) singles out John, given that this year John needs to publish at least three papers (any three will do), Mary at least two, and Bill at least one (cf. (7b)).

(25) the student who needs to publish the fewest papers
✓ the student whose requirements are the least demanding; i.e., the student x with the lowest number n_x, where n_i is the number of papers such that it is required for there to be at least n papers that i gets published

In a nutshell, then, the essential explanatory tradeoff between the approaches is this: Restrictionist analyses of relative superlatives are on the one hand simple and natural; essentially all uses of quantificational language are contextually restricted, so there is very little analytical overhead in postulating that relative "readings" emerge when the domains of superlative DPs are restricted in a particular way. On the other hand, it is a bit suspicious that the relevant, extremely robust pattern of relative readings should depend so systematically on the syntactic context of the superlative DP (Farkas & Kiss 2000, Coppock & Beaver 2014), without any semantic mechanism for capturing that context. In addition, there are well-described cases like (25) in which superlative DPs are indubitably at least locally indeterminate, and cannot therefore simply denote *the* element of their NP that maximizes some property (for further discussion of the indefiniteness of relative superlatives, see especially Szabolcsi 1986, 2012, Farkas & Kiss 2000, Coppock & Beaver 2014).

On the other hand, scopal analyses of relative superlatives explain how superlatives come to depend on the denotations of their syntactic contexts, as this is just what it *means* to take scope. However, to avoid the truth-conditional sting of indeterminacy, they are forced to stipulate an otherwise unattested alternation in the semantics of the definite article: exactly when the superlative morpheme takes extra-nominal scope, the article is interpreted indeterminately. Of course this last theoretical move — the assumption of semantically indeterminate uses of the definite article —- is of course open to restrictionist theories as well. Variants along these lines are explored in Coppock & Beaver 2014 and Krasikova 2012, discussed in Sections 4.4.2 and 4.4.1 respectively.

Before I compare these approaches with the one presented here (Section 4.3), I want to introduce the small literature on Haddock descriptions to emphasize the similar choice points that have emerged from competing analyses.

4.2 Haddock effects

Haddock (1987) originally observed that in the context of a model like Figure 7a, the description in (26) successfully refers to the rabbit R2, despite the fact that there are multiple salient hats and multiple salient rabbits in the scene.

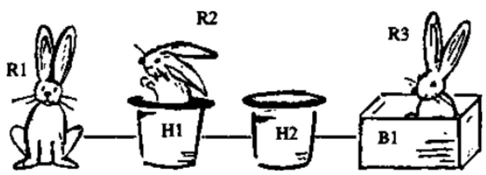
(26) the rabbit in the hat [Haddock 1987: (1)]

Though Haddock did not explicitly characterize the reference conditions of (26), his analysis makes it clear that he takes the description to identify a particular sort of *Constraint Satisfaction Problem* (Russell & Norvig 1995, Dechter 2003). He contends that the phrase is felicitous exactly when the context it is uttered in contains unique values for x and y that satisfy the following three simultaneous constraints: (i) x is a rabbit; (ii) y is a hat; and (iii) x is in y. In particular, the hat that (26) refers to needn't be the only hat in the model for the description to be well-formed, as long as there is exactly one *pair* of a rabbit and hat such that the rabbit is in the hat.

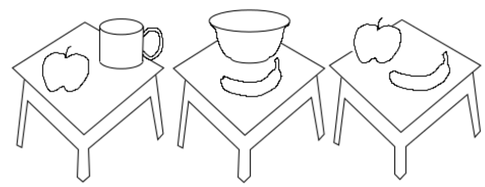
Haddock's CSP serves to highlight two things. First, it provides a nice characterization of the felicity conditions for (26): $\exists!\langle x, y\rangle$: $\mathsf{rabbit} \times \mathsf{hat}.\ \mathsf{in}\, y\, x$. Second, it illustrates the compositional trouble that (26) poses for theories of definiteness. The description contains two syntactically distinct definite DPs, but imposes what appears to be a single presupposition that quantifies *polyadically* over the potential referents of those descriptions.

Figure 7 Models supporting relative readings of definite determiners

(a) cf. (26) [pic. from Haddock 1987: p. 661]



(b) cf. (27) [pic. from Stone & Webber 1998: p. 185]



Subsequent work on natural language generation tasks have revealed that the phenomenon is not limited to cases in which a single definite description is nested within another. Horacek (1995) presents an example along the lines of (27), set against the model in Figure 7b, to demonstrate that the felicity of a description may depend on the simultaneous resolution of arbitrarily many referents. Here the success of (27) in referring to the rightmost table of Figure 7b suggests that the relevant felicity condition is something equivalent to $\exists!\langle x, y, z\rangle$: $\mathsf{apple} \times \mathsf{banana} \times \mathsf{table}.\ \mathsf{with}\, z\, (x \oplus y)$, where $x \oplus y$ is the mereological sum of x and y (Link 1983).

(27) the table with the apple and the banana [Horacek 1995]

Stone & Webber (1998) argue that the descriptions don't even need to be nested to co-depend on one another. They observe that the sentences in (28) are perfectly coherent things to say in the context of Figure 7a, despite its multiple rabbits and multiple hats. In both cases, though neither definite c-commands the other, the sentences appear to impose a single, joint uniqueness condition on rabbits and hats, namely, that there be a single pair such that it is possible to remove the one from the other, or possible for one to have been put in the other; in other words, that there be a single current rabbit-in-a-hat.

(28) a. Remove the rabbit from the hat.

b. Bill put the rabbit in the hat.

Analyses of Haddock's relative descriptions split along very similar fault lines as those of relative superlatives. Haddock (1987) himself, and later van Eijck (1993), adopted a dynamic view of referent identification in definite descriptions, which as I'll argue below, is a concrete (semantic!) means of implementing textbook restrictionist analyses. But Haddock and van Eijck are both silent about crucial compositional issues, most notably how to "delay" the effect of the embedded definiteness test until information from higher up in the tree has taken effect on the set of outputs.

For instance, van Eijck characterizes the denotation of (29a) in terms of the formula in (29b) ($\iota u.\ \pi$ here is the dynamic analog of the classical ι quantifier; it either remaps the variable u to the only entity d for which $\pi\, g^{u \mapsto d}$ doesn't fail, or else it crashes). If defined, the outputs in the denotation of this formula will all map the variable u to the unique character *that has a unique hat*, like the 'D' of model (29c). But how this logical form comes about, in which the embedded ι has scope over the predicate with, is not explained.

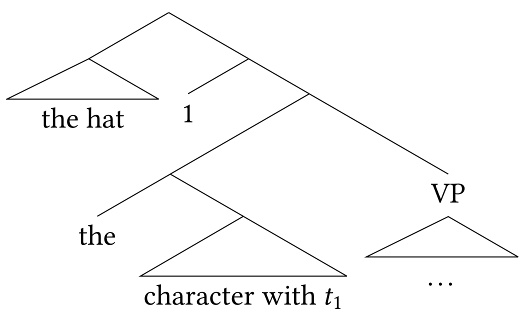
(29) a. the character with the hat [van Eijck 1993: (11-13)]

b. $\iota u.\, \mathsf{char}\, u\ ;\ \iota v.\, (\mathsf{hat}\, v\ ;\ \mathsf{with}\, v\, u)$

c. $\dddot{A}\ \ B\ \ \widehat{D}\ \ \frown\ \ E\ \ C\ \ \cdots\ \ \dddot{F}$

Champollion & Sauerland (2010) address precisely this issue. They argue that the embedded description is inversely linked to its host, relying on independently motivated assumptions about presupposition accommodation in the scope of quantifiers. For example, van Eijck's (29b) would correspond to the LF in (30). The scope of the linked definite — i.e., [[the character with t_1] ...] — presupposes the existence of a unique character with t_1. This presupposition is locally accommodated as an additional restriction on the wide-scoping determiner, so that 'the hat' in this configuration refers to the x such that x is a hat and there is exactly one character with x (see von Fintel 1994, Beaver 2001, Barker 1995, among others, for further discussion and examples of this sort of local accommodation).

(30)



Setting aside the formal kinks of this analysis,[4] it makes two bad empirical predictions. The first is that the description in (29a) will refer to the unique hat that sits atop *exactly one* character (if such a hat exists).[5] This is too weak. The proper felicity condition for such relative descriptions, as established by Haddock (1987), is that there be a unique *pair* $\langle x, y\rangle$ with x a hat, y a character, and y with x. Example (31) illustrates the difference. Champollion & Sauerland predict that the sentence in (31a) will be true in the model of (31b), as the only character with exactly one hat, 'D', is indeed a consonant. But in fact the sentence is not defined, since there are too many character-hat pairs that satisfy the subject.

(31) a. The character with the hat is a consonant

b. $\overparen{A\ B}\ \ \widehat{D}\ \ \frown\ \ \overparen{E\ C\ F}$

The second prediction is that relative readings should disappear when the embedded definite is in a full relative clause, rather than an argument or PP, because relative clauses are scope islands. It is easy to find attested counterexamples to this prediction (32). In fact when Champollion & Sauerland (2010) forced participants in an experimental study to choose between sentences like (33a) and (33b) as descriptions of a relative-reading model like (29c), they found that fully 76% of nearly 800 informants actually preferred to use the definite article to the indefinite one.[6]

4. The presupposition of the nuclear scope contains a bound variable. Conjoining this presupposition to the restrictor of the raised DP *unbinds* that variable!

5. Note that van Eijck (1993) makes the same prediction, though Haddock's (1987) original dynamic fragment (while admittedly sketchy on the details) does not.

6. Champollion & Sauerland (2010) actually take these results to argue *for* the inverse-linking analysis of relative readings, as the preference for (33a) over (33b) is slightly but significantly lower than the preference for (ia) over (iia). This drop notwithstanding, it is hard to see why 3 out of 4 speakers would still prefer a description which Champollion & Sauerland predict to be either undefined or island-violating to an alternative which is both shorter and clearly true.

(32) a. $^{\gamma}$ Metta World Peace is now friends with the guy who threw the beer at him
[at a basketball game, where there were presumably hundreds of beers]

b. $^{\gamma}$ Or maybe it's the tiny Laughing Buddha who's sitting there in front of the planter, throwing off little sparks of positive energy, that's keeping the plant so hale and hardy.
[describing an image with two planters, one of which is behind a Buddha figurine]

(33) a. The character that's under the hat is a consonant

b. The character that's under a hat is a consonant

So relative readings of embedded definites do not pattern with inverse readings of linked quantifiers, which are indeed unavailable when the linker is in a relative clause (Rodman 1976, May 1977). What's more, as illustrated in example (28), relative readings are not even limited to DP embeddings. In the context of Figure 7a, the rabbit and hat referents of (28) are just as mutually defining as they are in Haddock's classic nested example (26).

4.3 Synthesizing intuitions

In this section I suggest that the proposal here synthesizes scopal and restrictionist intuitions regarding relative readings of definites and superlative adjectives, avoiding some of the defects of both.

The first thing that I think is important to recognize is that essentially all DRT-ish dynamic fragments are restrictionist with respect to *indefinite* reference. The guiding principle behind such semantic frameworks is that indefinites introduce discourse referents, and predicates introduce constraints on the values of those referents. Thus when a predicate takes two indefinite arguments, the discourse referents will be in effect mutually constraining. Take the DRS in (34) for example. This diagram implicitly represents the set of models (or situations or assignment functions) in which there are referents for u and v that satisfy the simultaneous constraints $\mathsf{girl}\, v$, $\mathsf{boy}\, u$, and $\mathsf{see}\, v\, u$.

(34) a. A boy saw a girl

b.

u, v
$\mathsf{girl}\, v$ $\mathsf{boy}\, u$ $\mathsf{see}\, v\, u$

In other words, the outputs of dynamic systems by their nature encode the relational constraints that constituents impose on potential witnessing models. That is, as bits of meaning are built up, the assignments left open in the denotation of the structure are more and more constrained, which is to say, the set of outputs is increasingly *restricted* by the predicates that relate discourse referents. As a result, the long-hypothesized restriction of superlative descriptions to the constraints denoted by the predicates that surround them is an immediate consequence of the assumption that there is a dynamic existential lurking inside every definite article.

Where this analysis breaks ways with the restrictionist camp is that it allows the cardinality test of the definite and/or superlative adjective to take scope over the update denoted by its context. This means that locally, *in situ*, the relative DP behaves just as its indefinite shadow. This explains why relative DPs pass the spread of indeterminacy tests established by Szabolcsi 1986 and others (see Section 2.2). It also avoids the truth-conditional issues related to ties, either between highest-climbed mountains or highest-mountain climbers.

But at a distance, when the cardinality/maximality test is invoked, quantification plays out essentially as in Heimian scopal theories of superlatives, except that the set of alternatives that is quantified over is just the set of dynamic outputs generated at that point in the derivation. What's nice is that these outputs

(i) a. The character under the hat is a consonant

b. The character under a hat is a consonant are a natural byproduct of the dynamic framework. There's no need to reify the lambdas of QR so that the superlative morpheme can feed on an abstract node derived from movement (cf. Heim 1999: fn. 20). Instead, as in Alternative Semantics (Kratzer & Shimoyama 2002) or Focus Semantics (Rooth 1996), the compositional dynamic machinery carries the point of comparison up to the quantificational operator.

Furthermore, according to this analysis, though in the family of theories that attribute relative readings to the scope of the superlative, the definite article plays an important role in deriving relative readings. The superlative morpheme does not take scope in any usual sense, as it does not leave a trace and it does not bind anything. On the contrary, it is semantically quite simple; it filters out non-maximal outputs. It is the definite article that gives the filter scope over a more restricted set of outputs.

This explains several things. Most obviously, it accounts for the availability of the definite determiner in superlative DPs that are semantically indeterminate. Namely, the definite acts as a springboard for the scope of the quantificational adjective, and when it does so the uniqueness test it contributes does not quantify over the set of values that satisfy the NP it determines, but some more restricted set of values, and possibly much more abstract.

Second, it accounts for the lack of relative superlatives in the absence of the definite determiner, including indefinite superlatives, à la (24) (Herdan & Sharvit 2006), and possessive superlatives, à la (13c) (Chacón & Wellwood 2012). The possessive case is especially interesting, as neither the restrictionist nor the traditional scope-taking hypotheses have any explanation for the contrast between (13c) and (13b), repeated below. For restrictionist accounts, the question is what prevents the superlative of (35b) from considering only *climbed* mountains, given that it does so in (35a). For scopal accounts, the question is how to prevent the possessive determiner from shedding its definiteness in the presence of a superlative morpheme itching to quantify over the VP, given the capacity of the definite determiner to do so. The latter question is even more pressing in light of the fact that possessive DPs are in general more susceptible to indeterminate interpretations than definite DPs (see, e.g., Coppock & Beaver 2015 for a recent argument of this point).

(35) a. the guy who climbed the highest Scottish mountain

b. # the guy who climbed Scotland's highest mountain

Without committing to any particular semantic analysis of possessive DPs, suffice it to say that the analysis here at least has recourse in distinguishing between the scope-taking behavior of 'the' and that of '-'s'. In other words, the definite determiner is *special* in comprising two separable semantics processes. There's no reason to think the possessive determiner's semantics should be fractured in the same way. The absence of possessive Haddock readings, as demonstrated in example (14a), in fact suggests that it is not. Without this sort of subcomputational decomposition, there's no way for the cardinality test imposed (or not) by the determiner to quantify over anything but its nominal complement, and consequently no rocket with which to launch the superlative adjective into scope.

Here is a good place to own up to an unusual bullet that the present analysis has to bite. It predicts that 'the' takes superlative adjectives as arguments (or at least that it *can*), and thus that 'the' and 'longest', say, form a constituent in the DP 'the longest book'. This isn't entirely unprecedented. Szabolcsi (1986) and Krasikova (2012) both explore the possibility that 'the' and the superlative morpheme itself move together to the exclusion of the rest of the DP (in Szabolcsi's case, they form a kind of synthetic complex determiner; in Krasikova's the article takes the result of the superlative applied to a covert comparison class parameter as an argument). And similar constituency claims have surfaced for a handful of other arguably scope-taking adjectives, like ordinals (Svenonius 1994), adjectives of comparison (Svenonius 1994, Schwarz 2006, Kennedy & Stanley 2009), and adjectives of frequency (Larson 1999, Zimmermann 2003).

One suggestive data point in favor of the hypothesis that 'the' takes relatively-interpreted superlative adjectives as arguments is that relative readings disappear when a superlative adjective is separated from its definite determiner. To see this, first note that standard adjective-ordering conventions prefer the expression in (36a) to that in (36b).

(36) a. {the, a} thin peppy horse
b. *{the, a} peppy thin horse

With the superlative form 'peppiest', both orderings are possible, though they are not equivalent. If the superlative abuts the determiner, as in (37a), the description may be read absolutely (the thin horse that is peppier than any other thin horse) or relatively (a thin horse that was jockeyed by a third grader and peppier than any thin horse jockeyed by a different third grader). Yet in the original order (37b), only an absolute reading is available to the superlative (a horse peppier than any other).

(37) a. Which third grader rode the peppiest thin horse?
b. Which third grader rode the thin peppiest horse?

(38) a. [[which third grader] [est λdx [x rode [a thin d-peppy horse]]]]
b. [[which third grader] [est λdx [x rode [a d-peppy thin horse]]]]

Neither traditional scopal 'est' theories nor restrictionist theories predict this asymmetry. For instance, the logical forms in (38) are denotationally equivalent. In fact, given the equivalence of these LFs and the strong initial preference for (36a) over (36b), one might expect (37b) to be the natural way to express the relative question that (37a) expresses. In contrast, the account presented here predicts that relative readings will only arise when 'the' picks the superlative adjective up as an argument and (semantically) pied-pipes it to a higher perch.

4.4 Other points of comparison

4.4.1 Split definiteness

In a series of recent articles, Coppock and Beaver have pursued the idea that the traditional notion of "definiteness" conflates two semantically separable properties (Coppock & Beaver 2012a,b, 2014, 2015). Some descriptions are instantiated by at most one individual in a given context, either in virtue of the logical character of the description or in virtue of what information is in the common ground. These descriptions, they say, are *weakly unique* or *semantically definite*. Other descriptions are individual-denoting, type e. These they say are *determinate*. They observe that while all morphologically definite descriptions are weakly unique — setting aside the systematic class of so-called *weak definites* (Löbner 1985, Kadmon 1987, Poesio 1994, McNally 1998, Barker 2004) — not all such descriptions are determinate. In particular, they point to descriptions in predicative positions and descriptions containing superlative and exclusive adjectives as examples of weakly unique yet *indeterminate* definite descriptions. For instance, the most natural reading of (39) guarantees that there is no unique author of *Waverly*, and so the descriptive content 'only author of *Waverly*' cannot be individual-denoting (since is there is no such individual). Yet it is still weakly unique; there cannot be two distinct solo authors of the same text.

(39) Scott is not the only author of *Waverly* [Coppock & Beaver 2012b: (3b)]
≈ 'Scott is one of several authors of *Waverly*'

On the basis of such examples, they conclude that definite articles do not encode determinacy. That is, definite descriptions denote *sets* of individuals, just like indefinite descriptions. The only difference is that the sets denoted by definite descriptions are presupposed to have at most one individual in them. These descriptions are then coerced by familiar type-shifting operations (usually by ι-reduction, or in unusual cases like (39) by Partee's (1986) A) to facilitate composition.

The decomposition of $[\![\text{the NP}]\!]$ into two parts — $\{x \mid [\![\text{NP}]\!]\, x\}$ and $\lambda P.\, \iota x.\, P\, x$ — is very much in accord the proposal here. Interestingly, it is motivated not by examples of intervention effects, but by cases in which the ι part just never happens. Yet there are differences between Coppock & Beaver's decomposition and this one, the most important of which is that uniqueness (or, for them, weak uniqueness) is evaluated immediately, as soon as the NP is composed. Like most every other theory of definiteness, this is inconsistent with the Haddock data. There is nothing unique, or weakly unique, about the predicate 'hat' in Figure 7a.

It also makes rather dubious predictions about relative superlatives. Concentrating on the relative reading of (40), Coppock & Beaver (2014) propose a denotation for the superlative NP equivalent to (41) (assuming the y variables range over individuals in the comparison class).[7] This is the property of being a mountain climbed by someone which is taller than any mountain climbed by anyone else. This property is indeed indeterminate, as there can fail to be any such mountain when two distinct individuals climb equally tall mountains. But it is also *not* weakly unique. If John climbed five mountains (of potentially varying heights) all of greater magnitude than those scaled by any of his competitors, then *all five* of those mountains would meet the criterion in (41). So the alleged presupposition of the definite article here is not trivial. It predicts that (40) should be infelicitous in the context where John not only outclimbs his competitors but actually laps them. This, in my judgment, is not the case; I would say that when Erwin Schneider climbed Jongsong Peak (7,462 m) in 1939, besting the world record that he himself set at Nepal Peak (7,177 m) just two weeks prior, he did not thereby cease to be 'the alpinist who had scaled the greatest summit' (Smythe 2013).

(40) the person who climbs the tallest mountain

(41) $[\![\text{tallest mountain}]\!] =$
$$\lambda x\colon \mathsf{mtn}.\, \exists y.\, \mathsf{climb}\, x\, y \wedge \exists d.\, \mathsf{tall}\, x\, d \wedge \forall x'\colon \mathsf{mtn}.\, (\exists y'.\, y' \neq y \wedge \mathsf{climb}\, x'\, y') \Rightarrow \neg\, \mathsf{tall}\, d\, x'$$

It would be possible to avoid this prediction by adopting a more standard restrictionist view for the denotation of 'tallest mountain', given in (42), on which it is not mountain climbers that are compared but climbed mountains. This *is* weakly unique, as there is at most one climbed mountain that is higher than all others. But as Coppock & Beaver (2014: fn. 15) themselves point out, this fails to explain why (40) is false when several climbers, including John, all turn out to have scaled that unique highest climbed mountain.

(42) $[\![\text{tallest mountain}]\!] =$
$$\lambda x\colon \mathsf{mtn}.\, \exists y.\, \mathsf{climb}\, x\, y \wedge \exists d.\, \mathsf{tall}\, x\, d \wedge \forall x'\colon \mathsf{mtn}.\, (x' \neq x \wedge \exists y'.\, \mathsf{climb}\, x'\, y') \Rightarrow \neg\, \mathsf{tall}\, d\, x'$$

So while I am entirely sympathetic to the idea that definite descriptions denote, at some level, *indeterminate* sets of entities, I think it is essential, at least where Haddock and superlative descriptions are concerned, that the cardinality (and maximality) tests take effect later in the composition than the syntactic position of the definite article. (See Bumford 2016 for an extension of the analysis presented here to cases involving exclusive vocabulary like (39)).

7. Coppock & Beaver (2014) actually offer (i) as a denotation for the relative reading of 'tallest' in the context of (40), which they claim combines intersectively with the remaining nominal.

(i) $[\![\text{tallest}]\!] = \lambda x.\, \exists y.\, \mathsf{climb}\, x\, y \wedge \exists d.\, \mathsf{tall}\, x\, d \wedge \forall x' \forall y'.\, (y' \neq y \wedge \mathsf{climb}\, x'\, y') \Rightarrow \neg\, \mathsf{tall}\, d\, x'$

This however cannot be right. The tallest (climbed) tree is not an entity which is both a tree and taller than any other (climbed) entity. The variable x' needs to be restricted by the nominal just as the variable x does, which can't possibly happen by way of intersection.

4.4.2 Climber-indexed sets

Some years before Coppock & Beaver 2014, Farkas & Kiss (2000) mooted a very similar denotation for relatively-interpreted superlative DPs. As illustrated in (43), the meaning they hypothesize depends on the contextual resolution of two variables, the relativizing function f — generally the predicate of which the superlative DP is an argument — and the index i, which is intended to refer to the *correlate* of the superlative — the "victor" of the competition. The difference between Coppock & Beaver's superlative and Farkas & Kiss's is small; where Coppock & Beaver restrict the NP 'mountain' to just those that were climbed *by someone*, Farkas & Kiss restrict it to just those that were climbed *by John* (assuming John did indeed climb a mountain higher than anyone else).

(43) $[\![\text{tallest}_i \text{ mountain}]\!] = \lambda x.\, \mathsf{mtn}\, x \wedge f\, i\, x \wedge \forall x'\colon \mathsf{mtn}.\, (\exists j.\, j \neq i \wedge f\, j\, x') \Rightarrow \mathsf{height}\, x > \mathsf{height}\, x'$

The reason for introducing a second, referential index to the superlative DP is the same as in Coppock & Beaver: to guard against ties. Not only is the superlative searching for the largest climbed mountain (which could well have been climbed by several people), it is looking for a mountain climbed by i that is in addition higher than any mountain climbed by somebody other than i, where i is bound to the superlative's correlate. Unfortunately, while parameterizing the restricting relation f to individual climbers does indeed provide enough information for the superlative to fail in case of ties, it also predicts infelicity in case the victor climbs *several* mountains all higher than any mountains climbed by his or her competitors, just as with Coppock & Beaver 2014.

Taking a different tack, Krasikova (2012) proposes that 'est' quantifies over a contextually determined set of degree properties, perhaps the set containing for each furnace x the property $\lambda d.\, \mathsf{old}\, d\, x$, or perhaps the set containing for each homeowner y the property $\lambda d.\, \exists z\colon \mathsf{furn}.\, \mathsf{old}\, d\, z \wedge \mathsf{with}\, z\, y$. The superlative morpheme filters out all dominated degree properties within this set, and the definite article tests that the resulting set of maximal degree properties is unique. Essentially 'the [est C]', when C is interpreted relatively, denotes the set of all ages achieved by some homeowner's furnace. The full embedding description —- 'the homeowner with the oldest furnace' — then picks out the unique homeowner who for each one of these ages has *a* furnace at least that old.

Parts of Krasikova's story resonate with the analysis presented here. In particular the coupling of 'the' and 'est', using the latter to filter out non-maximal alternatives and 'the' to require a single winner. But the mechanism by which Krasikova effects these operations is quite different and not unproblematic. First, there is again a bit of awkwardness with ties. It could be that several relevant mountains, or mountain climbers, attain exactly the same sets of heights, in which case their distinct achievements would mistakenly register as a single degree property in C, since 'λd. John climbed a d-high mountain' and 'λd. Mary climbed a d-high mountain' will in this case identify *the same* function.

To sidestep the issue, Krasikova actually fills the field of comparison C with *intensional* degree properties, of the form 'λdw. john climbed$_w$ a d-high mountain$_w$'. Of course this relation between degrees and worlds will be different for John and Mary, as it is logically possible that they climbed mountains of different heights (for a finer point on this discussion, see Howard 2014: Section 4.2, which also sics the superlative operator on sets of intensional degree properties). I've included Krasikova's analysis in this subsection because neither the superlative nor the definite article make any use of the intensions of their arguments; the *only* reason for intensionalizing those constituents is to distinguish between, say, John's degree set and Mary's degree set. In this sense, the intensional denotations act as proxies for climber-indexed alternatives.

However, intensions are a suspect mechanism for keeping degree properties individuated by climber. In the first place, it is odd that the superlative and definite article should be necessarily intensional operators, given that to know who has the oldest furnace, it suffices to know only *actual* facts about people and their furnaces. Why should we even consider other possibilities? Second, allowing the definite article to count intensional witnesses of its argument seems doomed to undergenerate presupposition failures. After all, the *intension* of the noun 'boy' has only one value (the relation between worlds and the entities that are boys in those worlds), regardless of how many actual boys there are. Third, intensions are inadequate as an indexing proxy in the usual tautological situations. The sentence in (44) is predicted to be true, for instance, even though eight and six both maximize the function '$\lambda dw.\, x$ is a one-digit number with$_w$ d-many divisors$_w$'. But before you chuck this one in the general hyperintensionality basket, note that it is not a problem for any other analysis of superlatives. Scopal theories will compare one digit numbers to one another, searching for the one with more divisors than any other, but they won't find one. Traditional restrictionist theories will equate this use of 'the most divisors' with something like 'as many divisors as any one-digit number has', i.e., 'four divisors'. But then, again, there won't be any unique one-digit number with four divisors.

(44) Eight is the one-digit number with the most divisors

Neither does the dynamic theory espoused here have any trouble with this example. The denotation of the nominal will consist of a set of one-digit numbers paired with assignments. The assignments, which the superlative operator quantifies over, all map one variable u to the digit they are paired with and another variable v to the quantity of that digit's factors. The test of the outer definite in this case will fail, as there will be assignments with distinct u values but the same maximal quantities in v. All intension-free.

And this is the point. Assignment functions are naturally climber-indexed. The superlative does not quantify over mountains *or* mountain climbers. It quantifies over a set of outputs, each member of which is essentially a line in the great mountain-climbing ledger, a record of a single mountain-climbing accomplishment, complete with climber and mountain. This gives the superlative sufficient resolving power to break ties in the way that Farkas & Kiss, Coppock & Beaver, and Krasikova are careful to arrange, without relying on intensions or enforcing inappropriately strong conditions on how many mountains the best climber climbed.

4.4.3 Split numerals

Split-scope analyses of numeral determiners are more common, where modal intervention effects are well established (Cresti 1995, Heim 2000, Hackl 2000, Takahashi 2006, Abels & Martí 2010, Kennedy 2015). Intriguingly, Brasoveanu (2012) develops a dynamic fragment that decomposes modified numeral DPs like 'exactly three boys' into two components very similar to the components that are argued here to underly superlative DPs. Locally, the numeral DP contributes a maximal plural individual (e.g., the sum of relevant boys), assigned to some discourse referent u. This discourse referent interacts with the context in the expected way, supplying the argument for a verb or preposition or whatever. But independently, in a separate contextual register, the numeral DP also stashes a test, called a *postsupposition*, on the cardinality of individuals stored at u. This test is carried alongside the primary computation involving the boys stored in u, inert to all compositional processes, until the entire computation is evaluated for truth. At that point, the postsuppositions that have lingered in the context are run on the *output* of the update denoted by the sentence.

(45) Exactly three boys watched exactly five movies
$\approx$ 'the boys *who watched a movie* (cumulatively) watched the movies *that were watched by a boy*; there were exactly three of the former and exactly five of the latter'

Delaying the numerosity test of the numeral in this fashion allows subsequent semantic material to influence the shape of the output context before the cardinality of the relevant referent is evaluated. This is crucial for examples like (45). As indicated in the paraphrase below, (45) has a reading on which the number of movie-watching boys is three and the number of boy-watched movies five. Here the subject and object nominals *jointly* restrict the potential plural witnesses of the subject and object DPs, prior to any counting.

All of this is strikingly reminiscent of the analysis provided in Section 3. This is encouraging and opens the door to a potentially unified approach to all cardinality-testing vocabulary, including definite articles, in terms of filters on dynamic outputs. The major difference between the implementation in Brasoveanu 2012 and the one presented here is that here cardinality tests take scope, in a way that is familiar — at least in spirit — to all split-scope analyses; they are not themselves accumulated in a special dynamic cache, to be assessed only at the close of the computation. One advantage of a scopal approach to cardinality testing over a postsuppositional one is that it predicts the island effects reviewed in Section 2.4. However scope islands are enforced, they will delimit the reach of tests like $\mathbf{1}_u$ and $\mathbf{S}_u$. It is not clear what would prevent postsuppositions, as designed in Brasoveanu 2012, from trickling through island boundaries, given that they are formally invisible to nonpostsuppositional compositional material.

5 Conclusion

In this paper, I've explored the hypothesis that definite determiners are semantically comprised of two distinct compositional operations, one that builds sets of potential witnesses on the basis of the determiner's restrictor, and another that tests a set of witnesses for uniqueness along some dimension. In support of this hypothesis, I argued that Haddock readings of singular, plural, and cardinal definite descriptions, as well as relative readings of superlatives are all examples of definite descriptions whose witness-introducing and witnessing-testing components take differential scopes within a phrase. Splitting the scope of the determiner in this way explains why both Haddock definites and relative superlatives pattern with indefinites on a range of diagnostics: because locally, the "portion" of the denotation that is visible to the diagnostic environments *just is* indefinite. It also explains why the readings are sensitive to scope islands, as these projections delimit how high the split-off dynamic test can climb. Perhaps most interestingly, it explains why relative readings depend on the definite determiner — viz., the adjective's scope is parasitic on that of the definite's — in contrast with prevailing scope-based treatments of superlatives. Finally, it brings the semantics of definite articles in line with recent ideas about the semantics of other cardinality-testing nominal modifiers, especially numeral determiners.

A Formal analysis

The formal fragment here exploits the continuized mode of composition championed by Barker and Shan (Barker 2001, Barker & Shan 2008, 2014). The dynamic semantics is powered by the nondeterministic state monad, a technique developed in Charlow 2014 (see also Shan 2001).

A.1 Notation

Model Assumptions Models consist of entities, relations, and functions. Model-theoretic stuff is displayed in sans-serif, so, e.g., likes is the function that two arguments and returns true if the one likes the other.

Language and Metalanguage Lambda terms characterizing denotations may be syncopated, so that $\lambda x_0 \cdots x_n.\, M$ abbreviates $\lambda x_0.\cdots\lambda x_n.\, M$. Following Barker & Shan 2014, some lambda terms are visualized using "towers": $\dfrac{\cdots\,[\,]\,\cdots}{T} \equiv \lambda k.\, \cdots (k\, T) \cdots$

Bracketing Conventions Function application is left associative. Parentheses are omitted, except where necessary for grouping. Dots separate variable-binding operators from the expressions they scope over, and have lower precedence than everything except for braces and slashes.

A.2 Grammar and combinatorics

A.2.1 Types

Type Constructors Unary types include entities e, truth values t, and discourse contexts σ (modeled here as functions from variables to entities). Constructed types take one of the following forms, where α and β are any two types:

- $\alpha \to \beta$, the type of a function from α to β.
- $\{\alpha\}$, the type of a set of α objects.
- $\alpha * \beta$, the type of an α object paired with a β object, in that order.

Type Abbreviations To keep type descriptions readable, I use the following type synonyms:

- $\mathbb{D}_\alpha \equiv \sigma \to \{\alpha * \sigma\}$, the type of updates corresponding to constituents of type α.
- $\mathbb{K}_\alpha \equiv (\alpha \to \mathbb{D}_t) \to \mathbb{D}_t$, the type of generalized quantifiers with base type α and return type $\mathbb{D}_t$.
- $\mathbb{F}_\alpha \equiv \mathbb{D}_\alpha \to \mathbb{D}_\alpha$, the type of filters on updates.

The notation $m :: \alpha$ indicates that m is of type α.

A.2.2 Scope

$$m \mathbin{/\!\!/} n := \begin{cases} m\,n & \textbf{if } m :: \alpha \to \beta,\ n :: \alpha \\ \lambda k.\, m\left(\lambda f.\, n\left(\lambda x.\, k\left(f \mathbin{/\!\!/} x\right)\right)\right) & \textbf{otherwise} \end{cases}$$

$$m \mathbin{\backslash\!\!\backslash} n := \begin{cases} n\,m & \textbf{if } n :: \alpha \to \beta,\ m :: \alpha \\ \lambda k.\, m\left(\lambda x.\, n\left(\lambda f.\, k\left(x \mathbin{\backslash\!\!\backslash} f\right)\right)\right) & \textbf{otherwise} \end{cases}$$

$$m \parallel n := \begin{cases} \lambda x.\, m\,x \wedge n\,x & \textbf{if } m :: \alpha \to \beta,\ n :: \alpha \to \beta \\ \lambda k.\, m\left(\lambda x.\, n\left(\lambda f.\, k\left(f \parallel x\right)\right)\right) & \textbf{otherwise} \end{cases}$$

A.2.3 Binding

$$\eta\, x := \lambda g.\, \{\langle x, g\rangle\}$$
$$m^\star := \lambda k g.\, \bigcup \{k\,x\,g' \mid \langle x, g'\rangle \in m\,g\}$$

A.2.4 Evaluation

$$m^{\Downarrow} := \begin{cases} m\,\eta & \textbf{if } m :: (\alpha \to \mathbb{D}_\alpha) \to \beta \\ m\left(\lambda n.\, n^{\Downarrow}\right) & \textbf{otherwise} \end{cases}$$
$$m^{\Downarrow\!\Uparrow} := \left(m^{\Downarrow}\right)^\star$$
$$m^{\mathbb{I}} := \lambda k.\, m\left(\lambda n.\, k\, n^{\Downarrow}\right)$$

The grammar is essentially categorial, though I omit information about categories and work expressly with types, since the concerns here are entirely semantic. Composition is direct: any well-typed sequence of applications is predicted to have a meaning, and any object-language expression is expected to be ambiguous between the different ways of combining its constituent expressions using the combinators above. Also, note that technically only η, $\star$, and $/\!\!/$ are part of the grammar; the other combinators are just abbreviations for sequences of applications of those.

A.3 Basic definite descriptions

Item	*Type*	*Denotation*
rabbit	$e \to t$	rab
hat	$e \to t$	hat
in	$e \to e \to t$	in
$\textbf{some}_u$	$(e \to \mathbb{D}_t) \to \mathbb{K}_e$	$\lambda c k g.\, \bigcup \{k\,x\,g' \mid x \in \mathcal{D}_e,\ \langle \mathbf{T}, g'\rangle \in c\,x\,g^{u \mapsto x}\}$
$\textbf{the}_u$	$\mathbb{K}_{(e \to \mathbb{D}_t) \to \mathbb{K}_e}$	$\lambda k g.\, \mathbf{1}_u\, (k\, \textbf{some}_u)\, g$
$\mathbf{1}_u$	$\mathbb{F}_\alpha$	$\lambda m g.\, \begin{cases} G & \textbf{if } \lvert G_u\rvert = 1 \\ \emptyset & \textbf{otherwise} \end{cases}$, **where** $G = m\,g,\ G_u = \{g\,u \mid \langle \cdot, g\rangle \in G\}$

A.3.1 Basic Definite Descriptions

$[\![\text{the hat}]\!] =$

$$\left(\begin{array}{c}\mathbf{1}_v\,[\,]\\\hline \mathbf{some}_v\,(\lambda y.\,[\,])\\\hline y\end{array}\;\middle\|\;\begin{array}{c}[\,]\\\hline [\,]\\\hline \mathsf{hat}\end{array}\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow \left(\begin{array}{c}\mathbf{1}_v\,[\,]\\\hline \mathbf{some}_v\,(\lambda y.\,[\,])\\\hline \mathsf{hat}\,y\end{array}\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow \left(\begin{array}{c}\mathbf{1}_v\,[\,]\\\hline \mathbf{some}_v\,(\lambda yg.\,\{\langle\mathsf{hat}\,y,\,g\rangle\})\end{array}\right)^{\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_v\,[\,]\\\hline \lambda g.\bigcup\{[\,]\,g^{v\mapsto y}\mid \mathsf{hat}\,y\}\\\hline y\end{array}\right)^{\downharpoonleft\upharpoonright} \rightsquigarrow (\mathbf{1}_v\,(\lambda g.\,\{\langle y,\,g^{v\mapsto y}\rangle\mid\mathsf{hat}\,y\}))^{\star} \rightsquigarrow \lambda kg.\,k\,(\iota\,\mathsf{hat})\,g^{v\mapsto\iota\,\mathsf{hat}} \equiv \frac{\lambda g.\,[\,]\,g^{v\mapsto\iota\,\mathsf{hat}}}{\iota\,\mathsf{hat}}$$

A.3.2 Absolute Definite Reading

$[\![\text{the rabbit in the hat}]\!] =$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\\hline \mathbf{some}_u\,(\lambda x.\,[\,])\\\hline x\end{array}\;\middle\|\;\left(\begin{array}{c}[\,]\\\hline [\,]\\\hline \mathsf{rab}\end{array}\;\middle\|\;\begin{array}{c}[\,]\\\hline [\,]\\\hline \mathsf{in}\end{array}\;\middle/\!\!/\;\left(\begin{array}{c}\mathbf{1}_v\,[\,]\\\hline \mathbf{some}_v\,(\lambda y.\,[\,])\\\hline y\end{array}\;\middle\|\;\begin{array}{c}[\,]\\\hline [\,]\\\hline \mathsf{hat}\end{array}\right)^{\Downarrow\downharpoonleft\upharpoonright}\right)\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\\hline \mathbf{some}_u\,(\lambda x.\,[\,])\\\hline x\end{array}\;\middle\|\;\left(\begin{array}{c}[\,]\\\hline [\,]\\\hline \mathsf{rab}\end{array}\;\middle\|\;\begin{array}{c}[\,]\\\hline [\,]\\\hline \mathsf{in}\end{array}\;\middle/\!\!/\;\begin{array}{c}[\,]\\\hline \lambda g.\,[\,]\,g^{v\mapsto\iota\,\mathsf{hat}}\\\hline \iota\,\mathsf{hat}\end{array}\right)\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\\hline \mathbf{some}_u\,\left(\lambda xg.\,[\,]\,g^{v\mapsto\iota\,\mathsf{hat}}\right)\\\hline \mathsf{rab}\,x\wedge\mathsf{in}\,(\iota\,\mathsf{hat})\,x\end{array}\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow \left(\begin{array}{c}\mathbf{1}_u\,[\,]\\\hline \lambda g.\bigcup\left\{[\,]\,g^{\substack{u\mapsto x\\ v\mapsto\iota\,\mathsf{hat}}}\;\middle|\;\mathsf{rab}\,x,\ \mathsf{in}\,(\iota\,\mathsf{hat})\,x\right\}\\\hline x\end{array}\right)^{\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\left(\mathbf{1}_u\left(\lambda g.\,\left\{\left\langle x,\,g^{\substack{u\mapsto x\\ v\mapsto\iota\,\mathsf{hat}}}\right\rangle\;\middle|\;\mathsf{rab}\,x,\ \mathsf{in}\,(\iota\,\mathsf{hat})\,x\right\}\right)\right)^{\star} \rightsquigarrow \frac{\lambda g.\,[\,]\,g^{\substack{u\mapsto x\\ v\mapsto\iota\,\mathsf{hat}}}}{x},\ \textbf{where } x=\iota x.\,\mathsf{rab}\,x\wedge\mathsf{in}\,(\iota\,\mathsf{hat})\,x$$

A.3.3 Relative Definite Reading

$[\![\text{the rabbit in the hat}]\!] =$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\ \hline \mathbf{some}_u\,(\lambda x.\,[\,])\\ \hline x\end{array} \mathbin{/\!\!/} \left(\begin{array}{c}[\,]\\ \hline [\,]\\ \hline \mathsf{rab}\end{array} \parallel \begin{array}{c}[\,]\\ \hline [\,]\\ \hline \mathsf{in}\end{array} \mathbin{/\!\!/} \left(\begin{array}{c}\mathbf{1}_v\,[\,]\\ \hline \mathbf{some}_v\,(\lambda y.\,[\,])\\ \hline y\end{array} \mathbin{/\!\!/} \begin{array}{c}[\,]\\ \hline [\,]\\ \hline \mathsf{hat}\end{array}\right)^{\overline{\Downarrow}}\right)\right)^{\overline{\Downarrow}\,\downharpoonleft\!\upharpoonright}$$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\ \hline \mathbf{some}_u\,(\lambda x.\,[\,])\\ \hline x\end{array} \mathbin{/\!\!/} \left(\begin{array}{c}[\,]\\ \hline [\,]\\ \hline \mathsf{rab}\end{array} \parallel \begin{array}{c}[\,]\\ \hline [\,]\\ \hline \mathsf{in}\end{array} \mathbin{/\!\!/} \begin{array}{c}\mathbf{1}_v\,[\,]\\ \hline \lambda g.\,\bigcup\{[\,]\,g^{v\mapsto y} \mid \mathsf{hat}\,y\}\\ \hline y\end{array}\right)\right)^{\overline{\Downarrow}\,\downharpoonleft\!\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_u\,(\mathbf{1}_v\,[\,])\\ \hline \mathbf{some}_u\,(\lambda xg.\,\bigcup\{[\,]\,g^{v\mapsto y} \mid \mathsf{hat}\,y\})\\ \hline \mathsf{rab}\,x \wedge \mathsf{in}\,y\,x\end{array}\right)^{\overline{\Downarrow}\,\downharpoonleft\!\upharpoonright} \rightsquigarrow \left(\begin{array}{c}\mathbf{1}_u\,(\mathbf{1}_v\,[\,])\\ \hline \lambda g.\,\bigcup\left\{[\,]\,g^{\substack{u\mapsto x\\ v\mapsto y}} \,\middle|\, \mathsf{hat}\,y,\ \mathsf{rab}\,x,\ \mathsf{in}\,y\,x\right\}\\ \hline x\end{array}\right)^{\downharpoonleft\!\upharpoonright} \rightsquigarrow$$

$$\left(\mathbf{1}_u\left(\mathbf{1}_v\left(\lambda g.\,\left\{\left\langle x,\, g^{\substack{u\mapsto x\\ v\mapsto y}}\right\rangle \,\middle|\, \mathsf{hat}\,y,\ \mathsf{rab}\,x,\ \mathsf{in}\,y\,x\right\}\right)\right)\right)^{\star} \rightsquigarrow \frac{\lambda g.\,[\,]\,g^{\substack{u\mapsto x\\ v\mapsto y}}}{x},\ \textbf{where}\ \begin{array}{l} x = \iota x\colon \mathsf{hat}.\,\exists y.\,\mathsf{rab}\,y \wedge \mathsf{in}\,x\,y,\\ y = \iota y\colon \mathsf{rab}.\,\mathsf{in}\,x\,y\end{array}$$

A.4 Superlatives

Item	*Type*	*Denotation*
older	$e \to e \to t$	$\lambda xy.\,\mathsf{age}\,x > \mathsf{age}\,y$
$\mathbf{est}_u$	$(e \to e \to t) \to \mathbb{F}_\alpha$	$\lambda f mg.\,\{\langle \alpha, g\rangle \in m\,g \mid \neg\exists\langle \beta, g'\rangle \in m\,g.\,f\,(g'\,u)\,(g\,u)\}$
$\mathbf{S}_u$	$\mathbb{F}_\alpha$	$\mathbf{est}_u\,\mathsf{older} = \lambda mg.\,\{\langle \alpha, g\rangle \in m\,g \mid \neg\exists\langle \beta, g'\rangle \in m\,g.\,\mathsf{age}\,(g'\,u) > \mathsf{age}\,(g\,u)\}$
$\mathbf{the}_u$	$\mathbb{F}_\alpha \to \mathbb{K}_{(e\to\mathbb{D}_t)\to\mathbb{K}_e}$	$\lambda\mathbf{M}kg.\,\mathbf{1}_u\,(\mathbf{M}\,(k\,\mathbf{some}_u))\,g$

A.4.1 Basic Superlative Descriptions

$[\![\text{the oldest hat}]\!] =$

$$\left(\begin{array}{c}\mathbf{1}_v\,(\mathbf{S}_v\,[\,])\\ \hline \mathbf{some}_v\,(\lambda y.\,[\,])\\ \hline y\end{array} \mathbin{/\!\!/} \begin{array}{c}[\,]\\ \hline [\,]\\ \hline \mathsf{hat}\end{array}\right)^{\overline{\Downarrow}\,\downharpoonleft\!\upharpoonright} \rightsquigarrow \left(\begin{array}{c}\mathbf{1}_v\,(\mathbf{S}_v\,[\,])\\ \hline \mathbf{some}_v\,(\lambda yg.\,\{\langle \mathsf{hat}\,y,\, g\rangle\})\end{array}\right)^{\downharpoonleft\!\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_v\,(\mathbf{S}_v\,[\,])\\ \hline \lambda g.\,\bigcup\{[\,]\,g^{v\mapsto y} \mid \mathsf{hat}\,y\}\\ \hline y\end{array}\right)^{\downharpoonleft\!\upharpoonright} \rightsquigarrow \frac{\lambda g.\,\bigcup\{[\,]\,g^{v\mapsto y} \mid y = \iota y\colon \mathsf{hat}.\,\forall z\colon \mathsf{hat}.\,\neg\,\mathsf{older}\,z\,y\}}{y}$$

A.4.2 Absolute superlatives

$[\![\text{the rabus with the oldest hatuirrel}]\!] =$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\\hline \mathbf{some}_u\,(\lambda x.\,[\,])\\\hline x\end{array} \;\Big\|\; \left(\begin{array}{c}[\,]\\\hline[\,]\\\hline \mathsf{rab}\end{array} \;\Big\|\; \begin{array}{c}[\,]\\\hline[\,]\\\hline\mathsf{in}\end{array} \;/\!\!/\; \left(\begin{array}{c}\mathbf{1}_v\,(\mathbf{S}_v\,[\,])\\\hline\mathbf{some}_v\,(\lambda y.\,[\,])\\\hline y\end{array}\;\Big\|\;\begin{array}{c}[\,]\\\hline[\,]\\\hline\mathsf{hat}\end{array}\right)^{\Downarrow\downharpoonleft\upharpoonright}\right)\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\\hline \mathbf{some}_u\,(\lambda x.\,[\,])\\\hline x\end{array} \;\Big\|\; \left(\begin{array}{c}[\,]\\\hline[\,]\\\hline \mathsf{rab}\end{array} \;\Big\|\; \begin{array}{c}[\,]\\\hline[\,]\\\hline\mathsf{in}\end{array} \;/\!\!/\; \begin{array}{c}[\,]\\\hline \lambda g.\,\bigcup\{[\,]\,g^{v\mapsto y}\mid y=\iota y\colon \mathsf{hat}.\,\forall z\colon \mathsf{hat}.\,\neg\,\mathsf{older}\,z\,y\}\\\hline y\end{array}\right)\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\\hline \mathbf{some}_u\,(\lambda xg.\,\bigcup\{[\,]\,g^{v\mapsto y}\mid y=\iota y\colon \mathsf{hat}.\,\forall z\colon \mathsf{hat}.\,\neg\,\mathsf{older}\,z\,y\})\\\hline \mathsf{rab}\,x\wedge\mathsf{in}\,y\,x\end{array}\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\\hline \lambda g.\,\bigcup\left\{[\,]\,g^{\substack{u\mapsto x\\ v\mapsto y}}\;\middle|\;\begin{array}{l}\mathsf{rab}\,x,\;\mathsf{in}\,y\,x,\\ y=\iota y\colon \mathsf{hat}.\,\forall z\colon \mathsf{hat}.\,\neg\,\mathsf{older}\,z\,y\end{array}\right\}\\\hline x\end{array}\right)^{\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\begin{array}{c}\lambda g.\,\bigcup\left\{[\,]\,g^{\substack{u\mapsto x\\ v\mapsto y}}\;\middle|\;\begin{array}{l}x=\iota x\colon \mathsf{rab}.\,\mathsf{in}\,y\,x,\\ y=\iota y\colon \mathsf{hat}.\,\forall z\colon \mathsf{hat}.\,\neg\,\mathsf{older}\,z\,y\end{array}\right\}\\\hline x\end{array}$$

A.4.3 Relative superlatives

$[\![\text{the rabus with the oldest hat}]\!] =$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\\hline \mathbf{some}_u\,(\lambda x.\,[\,])\\\hline x\end{array} \;\Big\|\; \left(\begin{array}{c}[\,]\\\hline[\,]\\\hline \mathsf{rab}\end{array} \;\Big\|\; \begin{array}{c}[\,]\\\hline[\,]\\\hline\mathsf{in}\end{array} \;/\!\!/\; \left(\begin{array}{c}\mathbf{1}_v\,(\mathbf{S}_v\,[\,])\\\hline\mathbf{some}_v\,(\lambda y.\,[\,])\\\hline y\end{array}\;\Big\|\;\begin{array}{c}[\,]\\\hline[\,]\\\hline\mathsf{hat}\end{array}\right)^{\Downarrow}\right)\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_u\,[\,]\\\hline \mathbf{some}_u\,(\lambda x.\,[\,])\\\hline x\end{array} \;\Big\|\; \left(\begin{array}{c}[\,]\\\hline[\,]\\\hline \mathsf{rab}\end{array} \;\Big\|\; \begin{array}{c}[\,]\\\hline[\,]\\\hline\mathsf{in}\end{array} \;/\!\!/\; \begin{array}{c}\mathbf{1}_v\,(\mathbf{S}_v\,[\,])\\\hline \lambda g.\,\bigcup\{[\,]\,g^{v\mapsto y}\mid \mathsf{hat}\,y\}\\\hline y\end{array}\right)\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_u\,(\mathbf{1}_v\,(\mathbf{S}_v\,[\,]))\\\hline \mathbf{some}_u\,(\lambda xg.\,\bigcup\{[\,]\,g^{v\mapsto y}\mid \mathsf{hat}\,y\})\\\hline \mathsf{rab}\,x\wedge\mathsf{in}\,y\,x\end{array}\right)^{\Downarrow\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\left(\begin{array}{c}\mathbf{1}_u\,(\mathbf{1}_v\,(\mathbf{S}_v\,[\,]))\\\hline \lambda g.\,\bigcup\left\{[\,]\,g^{\substack{u\mapsto x\\ v\mapsto y}}\;\middle|\;\mathsf{hat}\,y,\;\mathsf{rab}\,x,\;\mathsf{in}\,y\,x\right\}\\\hline x\end{array}\right)^{\downharpoonleft\upharpoonright} \rightsquigarrow$$

$$\begin{array}{c}\lambda g.\,\bigcup\left\{[\,]\,g^{\substack{u\mapsto x\\ v\mapsto y}}\;\middle|\;\begin{array}{l}y=\iota y\colon G.\,\forall z\colon G.\,\neg\,\mathsf{older}\,y\,x,\\ x=\iota x\colon \mathsf{rab}.\,\mathsf{in}\,y\,x\end{array}\right\}\\\hline x\end{array},\ \textbf{where } G=\left\{x\;\middle|\;\begin{array}{l}\mathsf{hat}\,x,\;\mathsf{rab}\,y,\\ \mathsf{in}\,x\,y\end{array}\right\}$$

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