Distributivity, negation and quantification in event semantics: Recent work by L. Champollion

Roger Schwarzschild
Rutgers University/MIT
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Introduction

This note is about three recent papers on event semantics by Lucas Champollion. The first is titled "The Interaction of Compositional Semantics and Event Semantics" and I'll refer to it as *Interaction*. It offers a way to integrate two ways of doing semantics. On the first way of doing business, we have meanings like those in (1), and function-argument application is the standard rule for combining meanings.

(1) Montague style meanings

Every robot $\rightsquigarrow \lambda P\ \forall x[\mathbf{robot}(x) \rightarrow P(x)]$

and$_{<et,et>} \rightsquigarrow \lambda P.\ \lambda Q.\ \lambda x[P(x) \wedge Q(x)]$

not$_{<et,et>} \rightsquigarrow \lambda P.\ \lambda x\ \neg P(x)$

walks$_{<e,t>} \rightsquigarrow \mathbf{walk}$

Every robot walks but doesn't talk $\rightsquigarrow \forall x[\mathbf{robot}(x) \rightarrow [\mathbf{walk}(x) \wedge \neg\mathbf{talk}(x)]]$

On the second way of doing business, constituents of a sentence contribute predicates of an event variable which is existentially quantified, giving us meanings such as in (2) below:

(2) Davidson style meanings

Jack laughed quietly $\rightsquigarrow \exists e\ [\mathrm{Ag}(e){=}\mathbf{jack} \wedge \mathbf{laugh}(e) \wedge \mathbf{quiet}(e)]$

There are several empirical phenomena covered in *Interaction*[1]. The ones that will receive the most attention here are negation, DP quantification and durational *for*-adverbials.

The next two papers are about distributivity. Their titles are "*Overt* Distributivity in Algebraic Event Semantics" and "*Covert* Distributivity in Algebraic Event Semantics" and I'll refer to them as *Overt* and *Covert* respectively. These papers offer interesting insights about how distributivity works in natural language. The analyses are couched in an event semantics of the kind illustrated in (2) above. Ultimately we'd like to believe that the insights captured in *Overt* and *Covert* are preserved when phenomena like those studied in *Interaction* are brought in. The specific question that will occupy us here is to what degree the analyses of distributive operators and *for* adverbials found in *Overt* and

[1] Champollion cites the following papers with goals similar to that of *Interaction*: Beaver and Condoravdi(2007), Eckardt(2010) and Winter and Zwarts(2011).

Covert can be carried over to the system developed in *Interaction*. *Overt* and *Covert* cover a broad range of phenomena. I will focus narrowly on adnominal *each* and adverbial *each*, illustrated in (3)-(4) below, as well as on durational *for*-adverbials.

(3) They each wrote 2 poems. (adverbial *each*)

(4) They wrote 2 poems each. (adnominal *each*)

I'll begin by introducing the papers and then we'll see about trying to integrate them. This note presupposes familiarity with plural semantics.

Interaction

In (2) above, the existential quantifier comes at the head of the formula. A natural assumption is that existential closure happens at the top of a clause. This allows constituents within the clause to jointly describe the same variable before it gets closed off. Problems arise when negation and quantifiers are encountered along the way. The meanings in (5)b. and (6)b. are not right for the sentences in (5)a. and (6)a.

(5) a. Jack didn't drink
b. $\exists e\ \neg[\mathbf{drink}(e) \wedge \mathbf{ag}(e)=\mathbf{jack}]$

(6) a. Every dog barked.
b. $\exists e\ [\forall x[\mathbf{dog}(x) \rightarrow [\mathbf{bark}(e) \wedge \mathbf{ag}(e)=x]]$

(5)b. is a very weak statement, one that is made true say by the event of my writing this sentence. As for (6), assuming that an event can have at most one agent and that there are many dogs, (6)b. couldn't be true, but (6)a. could. In both (5) and (6), the correct meanings would be gotten by lowering the scope of '$\exists e$'.

Champollion solves this problem by including the existential quantification in the meaning of the verb itself. This gets the right scope relative to negation, but now the problem becomes how to add content above the verb as predicates of the event variable. This problem is solved by raising the type of the verb. I will now illustrate how that works.

We'll start with the verb *rain*, as in *it is raining*. On the *Interaction* approach, the verb gets the meaning below:

(7) $\textit{rain} \rightsquigarrow \lambda f.\ \exists e[\mathbf{rain}(e) \wedge f(e)]$

Abstracting away from tense and aspect and assuming the verb *rain* takes no arguments, (7) is almost the meaning of *it is raining.* What's missing is the final closure step in which the meaning in (7) is applied to the set of all events, which Champollion writes as '$\lambda e.\mathbf{true}$'. So the meaning of *it's raining* comes out as:

(8) $\lambda f.\ \exists e[\mathbf{rain}(e) \wedge f(e)](\lambda e.\mathbf{true})$

$= \exists e[\mathbf{rain}(e) \wedge (\lambda e.\mathbf{true})(e)]$

$= \exists e[\mathbf{rain}(e) \wedge \mathbf{true}]$

$= \exists e.\ \mathbf{rain}(e)$

As (8) shows, the end result is logically equivalent to a simple existential event statement. You might be wondering why we don't just interpret the verb directly as '$\exists e\ \mathbf{rain}(e)$'. To see the benefit of the higher type meaning in (7), let's consider how manner adverbials work:

(9) *heavily* $\rightsquigarrow$ $\lambda V.\ \lambda f.\ V(\lambda e.[\mathbf{heavy}(e) \wedge f(e)])$

(10) *rain heavily* $\rightsquigarrow$ $[\lambda V.\ \lambda f.\ V(\lambda e.[\mathbf{heavy}(e) \wedge f(e)])]\ (\lambda f.\ \exists e[\mathbf{rain}(e) \wedge f(e)])$

$= [\lambda V.\ \lambda f.\ V(\lambda e.[\mathbf{heavy}(e) \wedge f(e)])]\ (\lambda \mathrm{f}'.\ \exists e[\mathbf{rain}(e) \wedge \mathrm{f}'(e)])$

$= \lambda f.\ [\lambda \mathrm{f}'.\exists e[\mathbf{rain}(e) \wedge \mathrm{f}'(e)]]\ (\lambda e.[\mathbf{heavy}(e) \wedge f(e)])$

$= (\lambda f.\ \exists e.\ [\mathbf{rain}(e) \wedge \mathbf{heavy}(e) \wedge f(e)]$

The '$f(e)$' conjunct is carried along and each time it gets 'replaced' with a new conjunct that includes the additional event description. The '$f(e)$' conjunct in (7) has been replaced in (10) with '$\mathbf{heavy}(e) \wedge f(e)$'. After closure we get:

(11) $\exists e.\ [\mathbf{rain}(e) \wedge \mathbf{heavy}(e)]$

In this system, negation is defined as:

(12) *not* $\rightsquigarrow$ $\lambda V.\ \lambda f.\ \neg V(f)$

giving us:

(13) *not rain heavily* $\rightsquigarrow$ $\lambda f.\ \neg\exists e[\mathbf{rain}(e) \wedge \mathbf{heavy}(e) \wedge f(e)]$

And with the final closure operation we have (14):

(14) *it is not raining heavily* $\rightsquigarrow$ $\neg\exists e\ \mathbf{rain}(e) \wedge \mathbf{heavy}(e)$

As desired, negation is above the event existential '$\exists e$' and the modifier is below.

Exercise

Verify that the result in (13) can be gotten by applying negation to the meaning of *rain heavily,* as well as by applying the meaning of *heavily* to that of *not rain.* In other words:

(15) not(rain heavily) ≡ ((not rain) heavily)

Do you detect a scopal ambiguity in *it wasn't raining heavily*? If not, the result in (15) is a good one.

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A helpful way to review what we've covered so far is by focusing on semantic types. The variable 'f' ranges over event-predicates, so it's type is $\langle v,t\rangle$, where v is the type of events. Big 'V' is a variable of type $\langle\langle v,t\rangle,t\rangle$, which is the type of verbs, as (7) shows (mnemonic: 'V' is for verb). And because 'V' is type $\langle\langle v,t\rangle,t\rangle$, expressions that begin with 'λV' can apply to verb meanings. Both *heavily* and *not* have meanings that being with 'λV'.

Now we come to the second problem, quantificational arguments of the verb. Our goal will be to produce meanings like in (16) below:

(16) *every robot walks* $\rightsquigarrow \lambda f.\ \forall x[\mathbf{robot}(x) \rightarrow \exists e[\mathbf{walk}(e) \wedge \mathbf{ag}(e){=}\ x \wedge f(e)]]$

When (16) is closed we get:

(17) $\forall x[\mathbf{robot}(x) \rightarrow \exists e[\mathbf{walk}(e) \wedge \mathbf{ag}(e){=}\ x]]$

which correctly gives the universal quantifier scope over the event-existential. To get the meaning in (16), we'll need to have a meaning for the subject of *every robot walks* that will apply to the meaning of the verb given below and return (16).

(18) *walk* $\rightsquigarrow\ \lambda f.\ \exists e[\mathbf{walk}(e) \wedge f(e)]$

In order to figure out what the meaning of the subject should be, it's useful to look again at the meanings we have for *not* and for *heavily*:

(19) *not* $\rightsquigarrow \lambda V.\ \lambda f.\ \neg V(f)$

(20) *heavily* $\rightsquigarrow\ \lambda V.\ \lambda f.\ V(\lambda e.[\mathbf{heavy}(e) \wedge f(e)])$

In both cases, we have a meaning that starts with:

$\lambda V.\ \lambda f.$

'λV' allows application to verb meanings and 'λf' produces verb-type meanings. As with negation, we'll need something that comes before the application of V since V contains the event-existential, so that gives us:

$\lambda V.\ \lambda f.\ \forall x[\mathbf{robot}(x) \rightarrow$

finally, like with *heavily,* we want to 'replace' the *f* part of the verb with a statement with a new conjunct, this time one that includes mention of the agent. That gives us:

(21) *every robot*-[ag] $\rightsquigarrow$ $\lambda V.\ \lambda f.\ \forall x[\mathbf{robot}(x) \rightarrow V(\lambda e[\mathbf{ag}(e) = x \wedge f(e)])]$

Combining (21) with the meaning of *walk* in (18) gives us the desired (16) above.

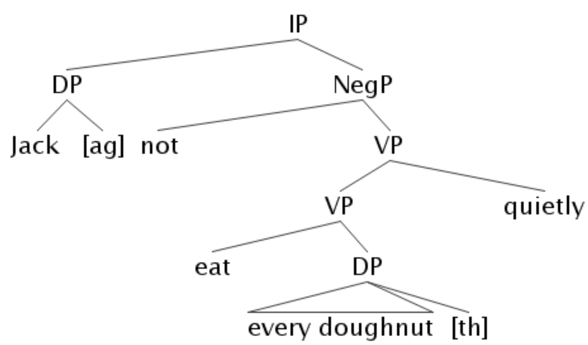
In (21), we gave the meaning of *every robot* combined with the agent role. Champollion assumes that "thematic roles…are provided by separate syntactic heads" that are combined with DPs. If one looks at (21), one can see bits of the generalized quantifier meaning for *every robot,* the one given earlier in (1). The meaning for [ag] is whatever it takes to produce (21) from the standard generalized quantifier meaning in (1). That is given below in (22) and we have corresponding meanings for other thematic roles:

(22) [ag] $\rightsquigarrow$ $\lambda Q\ \lambda V\ \lambda f.\ Q(\lambda x[V(\lambda e[\mathbf{ag}(e) = x \wedge f(e)])])]$

Except for the durational *for*–adverbials, to be introduced later, that sums up the part of *Interaction* that will interest us here. The remainder of this section consists of exercises to practice getting used to how the system works. The first three exercises are relevant to subsequent discussion but I will not be presupposing that the reader has looked at them.

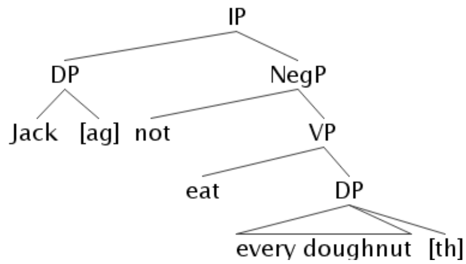
Exercises

1. Calculate the meaning of *Jack didn't eat every doughnut quietly*. Use the syntactic structure given below. Assume that the meaning of *Jack* is $\lambda P.P(\mathbf{jack})$. The meanings for the other words and for the theme role head '[th]' should be straightforward given previous discussion.

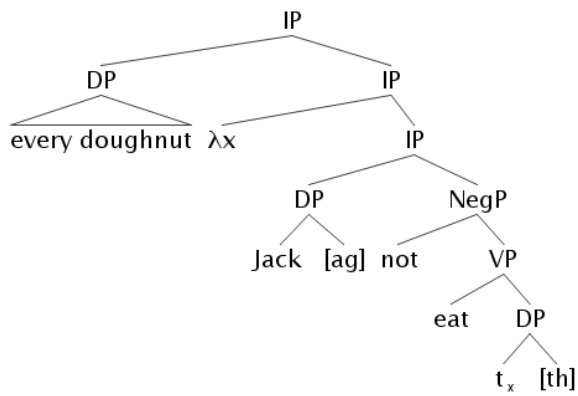


In the tree above, *quietly* takes syntactic scope over *every doughnut*-[th]. Would the resulting meaning be different if you had ((*eat quietly*) (*every doughnut*))? In the sentence *Jack ate every doughnut quietly*, do you perceive any scopal ambiguity arising from the object and the adverb? Can you find other manner adverbs that give rise to a scopal interaction with universal objects?

2. Below is a structure for *Jack didn't eat every doughnut*. Write the meaning assigned to that structure.



Champollion discusses ways of producing 'inverse scope'. He and his predecessors disfavor QR, nevertheless we can ask how QR might work in this system. Let's assume that DPs can raise and adjoin to higher nodes with a λ-prefix inserted and interpreted as a λ-prefix. Applying this rule to the tree above we get:

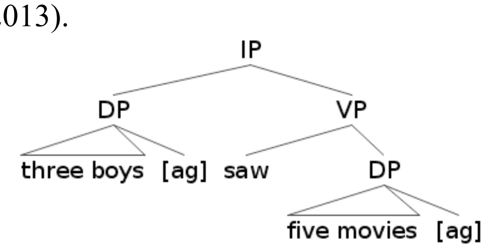


Calculate the meaning assigned to this tree assuming that traces have type $\langle\langle e,t\rangle,t\rangle$ interpretations:

(23) $t_x \rightsquigarrow \lambda P.\ P(x)$

Is the result of your calculation different from what you got for the tree without QR? I've assumed that the DP moves without its thematic role head sister. Is it possible to instead raise the whole DP including the thematic role head?

3. In the following section we'll be taking up plurals. As a warm-up calculate the meaning assigned to the tree below for the sentence *Three boys saw five movies* from Brasoveanu(2013).



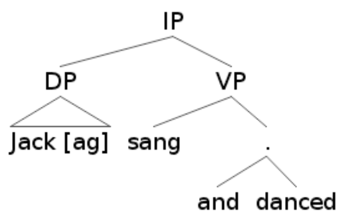
Assume the following meanings:

(24) *three boys* $\rightsquigarrow \lambda P\, \exists x[\mathbf{boys}(x) \wedge |x|=3 \wedge P(x)]$

(25) *five movies* $\rightsquigarrow \lambda P\, \exists y[\mathbf{movies}(y) \wedge |x|=5 \wedge P(x)]$

4. Calculate the meaning of *Jack sang and danced* using the meaning below for *and*:

(26) *and* $\rightsquigarrow\ \lambda V.\, \lambda V'.\, \lambda f.\ [V(f) \wedge V'(f)]$



What problem arises when you conjoin verbs whose subject have different thematic roles? Can you suggest a solution? This issue is discussed in §5 of *Interaction*.

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Overt Distributivity

We'll consider the events that took place during a recent breakfast encounter to work our way towards the semantics for adverbial *each* found in *Overt.*

Jack and Jill had breakfast. Jack had one egg. Jill had one egg. That makes two events of egg eating, one whose agent is Jack and the other whose agent is Jill. Champollion takes entities in the denotation of a singular count noun such as *person* to be 'atomic' in the algebraic sense. So the egg eating events just mentioned can be described as atomic-agent events. These two atomic-agent events make up a third event of eating, *e*, in which both eggs were eaten. The agent of *e* is not atomic. The agent of *e* is a plurality consisting of Jack and Jill. Here is a summary:

(27) There was an event *e*
Jack and Jill are the agents of *e*
e is a sum of e' events, where an e' event is an atomic-agent event in which 1 egg is eaten.

The last line sums together events, each of which fits a description that can captured with the lambda expression in (28) below (the last conjunct '$\mathbf{egg}(\mathbf{th}(e'))$' says that the theme of e' was an egg)

(28) $\lambda e'\ [\mathrm{Atom}(\mathbf{ag}(e')) \wedge \mathbf{eat}(e') \wedge \mathbf{egg}(\mathbf{th}(e'))]]$

Using (28) and the $*$-operator that closes a set under summation, we capture the whole last line of (27) as:

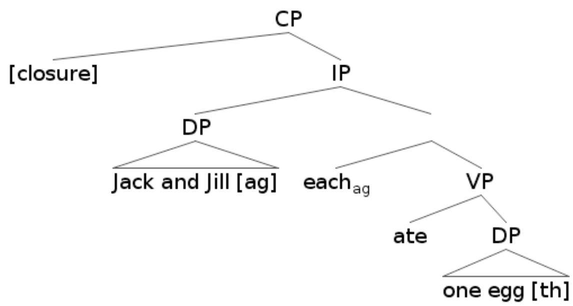
(29) $e \in {}^*\lambda e'\ [\mathrm{Atom}(\mathbf{ag}(e')) \wedge \mathbf{eat}(e') \wedge \mathbf{egg}(\mathbf{th}(e'))]]$

The $*$ operator gives us a set of sums of atomic-agent events. One of those sums happens to be the result of adding Jack's and Jill's egg eating. The '$e \in$' says that e is in that set so it is a sum of atomic-agent events. Notice that the expression in (29) doesn't include a universal quantifier, '$\forall$', common in work on distributivity. Distributive operators in *Overt* and *Covert* all include expressions of the form '$e \in {*}\lambda e' \ldots$'. I'll refer to this approach as 'sum-distributivity'.

Using (29) and other features of *Overt*, we get the following meaning:

(30) *Jack and Jill each ate one egg* $\rightsquigarrow$
$$\exists e[\mathbf{ag}(e)=\mathbf{jack{+}jill} \wedge e \in {*}\lambda e' \,[\text{Atom}(\mathbf{ag}(e')) \wedge \mathbf{eat}(e') \wedge \mathbf{egg}(\mathbf{th}(e'))]]]$$

Notice that '**ag**' appears twice in the formula in (30). The first occurrence is associated with a thematic role head adjacent to the subject. The second involves a novel use of thematic roles whereby they are coindexed with distributivity operators. The meaning in (30) results from a structure like the one below:



There is discussion in *Overt* about how to interpret thematic role heads. For our purposes, it is sufficient to know what meanings are assigned to the constituents represented above. They are listed below (note: in *Overt*, verbs denote one place event predicates and the variable V ranges over 1-place event predicates.):

ate $\rightsquigarrow \lambda e.\ \mathbf{eat}(e)$

one egg [th] $\rightsquigarrow \lambda e\ [\mathbf{egg}(\mathbf{th}(e))]$

ate (*one egg*)[th] $\rightsquigarrow \lambda e\ [\mathbf{eat}(e) \wedge \mathbf{egg}(\mathbf{th}(e))]$

each$_{\text{ag}}$ $\rightsquigarrow \lambda V\, \lambda e.\ e \in {*}\lambda e'[\text{Atom}(\mathbf{ag}(e') \wedge V(e'))]$

each$_{\text{ag}}$ *ate* (*one egg*)[th] $\rightsquigarrow \lambda e.\ e \in {*}\lambda e'[\text{Atom}(\mathbf{ag}(e') \wedge \mathbf{eat}(e') \wedge \mathbf{egg}(\mathbf{th}(e'))]$

Jack and Jill [ag] $\rightsquigarrow \lambda e\ [\mathbf{ag}(e)=\mathbf{jack{+}jill}]$

[$_{\text{IP}}$*Jack and Jill* [ag] *each*$_{\text{ag}}$ *ate* (*one egg*)[th]] $\rightsquigarrow$

$$\lambda e\ [\mathbf{ag}(e)\text{=}\mathbf{jack{+}jill} \wedge e \in {}^*\lambda e'[\mathrm{Atom}(\mathbf{ag}(e') \wedge \mathbf{eat}(e') \wedge \mathbf{egg}(\mathbf{th}(e'))]$$

[closure] $\rightsquigarrow \lambda V\, \exists e.\ V(e)$

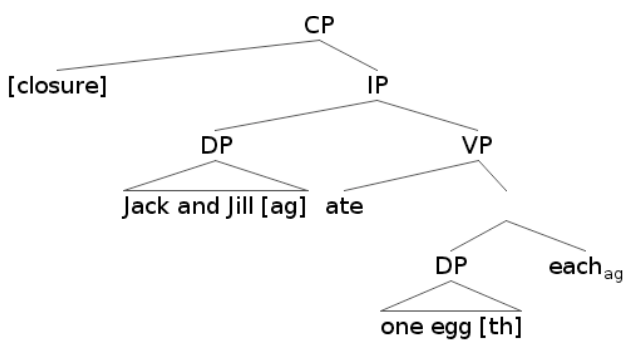
Except for *each* and [closure], the mode of combination is generally intersection. In *Overt*, numerical DPs like *one egg* and *exactly 3 movies* are treated as one place predicates. This appears to be motivated by concern for co-occurrence restrictions with adnominal *each*. With an eye towards integration with the system in *Interaction*, it is worth noting that the following meaning assignment would do as well as (30):

(31) *Jack and Jill each*$_{\mathrm{ag}}$ *ate one egg* $\rightsquigarrow$
$$\exists e[\mathbf{ag}(e)\text{=}\mathbf{jack{+}jill} \wedge e \in {}^*\lambda e'[\exists z.\ \mathbf{egg}(z) \wedge \mathrm{Atom}(\mathbf{ag}(e')) \wedge \mathbf{eat}(e') \wedge \mathbf{th}(e') = z)]]]$$

The sentence in (31) features an adverbial *each* but it is synonymous with (32) below with adnominal *each*:

(32) Jack and Jill ate one egg each.

Champollion follows Safir and Stowell and subsequent work in taking adnominal *each* (a.k.a 'binominal *each*') to form a constituent with its *host* DP. Let's assume the following structure.



In this tree, *each*$_{\mathrm{ag}}$ combines with a DP not a VP, but that is unproblematic. The meanings assigned to *each*$_{\mathrm{ag}}$ and the DP above combine via function argument application. So, combining the meanings used earlier, we get:

(33) $\exists e\ [\mathbf{ag}(e)\text{=}\mathbf{jack{+}jill} \wedge \mathbf{eat}(e) \wedge e \in {}^*\lambda e'[\mathrm{Atom}(\mathbf{ag}(e') \wedge \mathbf{egg}(\mathbf{th}(e'))]$

(33) accurately describes Jack and Jill's breakfast, since there was that two-egg eating event of which they were the agents and it was the sum of atomic-agent events in each of which an egg was theme. So this looks like a good analysis – and it is worth pausing here to appreciate how startlingly smooth the transition was from adverbial to adnominal *each*.

If we compare (33) with (30), we notice that the meaning associated with the verb has shifted relative to the sum-distributive statement '$e \in {}^*\lambda e'$...'. This is a direct result of the fact that adverbial *each* combines with a constituent that includes the verb while adnominal *each* does not. This difference extends to other expressions that might be contained in a verb phrase. Champollion cites the following pair from LaTerza(2014):

(34) John and Bill each served four meals to (exactly) three judges.

(35) John and Bill served [four meals each] to (exactly) three judges.

(34) has a reading according to which John served four meals to three judges and Bill did too. (35) has a reading according to which where there were three judges that were served by John and Bill, John served them four meals and Bill did too. In the first case, adverbial *each* takes *to three judges* in its syntactic scope and the distribution encompasses the judges. In the second case, *to three judges* is outside the scope of adnominal *each* and the judges are external to the distribution. (For other types of examples where adnominal *each* takes narrow scope see *Covert* page 23, (89) and (90)).

In the examples used so far, *each* was always coindexed with an agent thematic role head. Adnominal *each* allows for other possibilities:

(36) The waiter served Jack and Jill one egg $\text{each}_{\text{Goal}}$ (one egg per goalie)
(37) The manager sent Jack and Jill to two stores each_{th}. (2 stores per theme-sendee)

We have now the essentials of the *Overt* analysis of adnominal and adverbial *each*. In the next section, we'll attempt an analysis of *each* within the *Interaction* framework.

side remarks event-based distributivity operators **(optional)**

In the remainder of this section, I want to very briefly explore consequences of the treatment of adnominal *each* and I'd like to allude to the bigger picture offered in *Overt* and *Covert*. This discussion is not directly relevant to our main goal.

Recall that in the meaning for (32), repeated below, the verb meaning occurs outside the scope of $e \in {}^*\lambda e'$.

(38) *Jack and Jill ate one egg each* $\rightsquigarrow$

$$\exists e\,[\mathbf{ag}(e)\mathbf{=jack+jill} \wedge \mathbf{eat}(e) \wedge e \in {}^*\lambda e'[\text{Atom}(\mathbf{ag}(e') \wedge \mathbf{egg}(\mathbf{th}(e'))]$$

As far as I can tell, nothing in the formula or in the background assumptions guarantees that the e's, the atomic-events in which an egg is theme, are in fact events of eating. What if the atomic e' events were not eating events? In this example and in many of the ones Champollion considers, this worry is not pressing. What else could these e's be if together they make up an eating? But consider the following scenario. A playful group of artists get together and decide to build a wall of books on the sidewalk. The first one places a book on the sidewalk, the second one places another book next to it, and so on, with each artist putting one book down next to or on top of other books until a wall is built. In that case, the following seems true:

(39) $\exists e\, [\mathbf{ag}(e) = \mathbf{the.artists} \wedge \mathbf{build}(e) \wedge\ e \in {}^*\lambda e'[\mathrm{Atom}(\mathbf{ag}(e') \wedge \mathbf{book}(\mathbf{th}(e'))]$

But the true (39) is our meaning for the sentence in (40) below which is intuitively not true:

(40) The artists built one book each_{ag}.

I can imagine two types of responses. One is to say that thematic roles are more fine-grained than so far represented. In (39), we have **th** but if that is supposed to be the thematic role head adjacent to the object in (40), then it should be something more specific about building, maybe '($\mathbf{build}$=$\mathbf{th}(e')$)'. If (39) is modified that way, then it no longer accurately describes what the artists did, since the books were not build-themes. Another option is to simply deny that the sum of the book placing events is the building event. This alternative is inspired by the discussed in section 3.3 (page 13) of Champollion and Krifka(2014), to which readers of *Covert* are referred (page 15) for an overview of linguistic applications of mereology. On this alternative, the wall-building event is distinct from the event which is the sum of all the book placing events. This type of fine-grainedness is common in event semantics – it comes with the territory. But if we are going this route, it isn't clear to me why we want to invoke mereology in the compositional semantics. *build* is true of events of building, including pluralities of building events. The fact that the set of book-placing events overlaps and even intuitively 'adds up' to the wall-building is not relevant. So why identify these pluralities with mereological sums in the first place?[2]

The other question that arises with narrow scope adnominal *each* has to do with the fact that while it allows for narrow scope readings –it doesn't always seem to require them. Consider this example, which is like LaTerza's:

(41) Jack and Jill shampooed 3 dogs each with just two bottles of shampoo.

I think that example is ambiguous. It can report on a shampooing where the two bottles were jointly used by Jack and Jill. That's the predicted narrow scope reading of adnominal *each*. But I think (41) can also be used to report on a shampooing in which Jack used two bottles and Jill did too. Does that mean we need to somehow allow adnominal *each* or the DP it is attached to take scope over the adverbial? Maybe not. Another possibility is that we have a covert distributor on the instrumental PP (see Figure 4 page 28 of *Overt* for this use). It would come out like the following:

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[2] I haven't studied Champollion & Krifka(2014). I suspect there is some discrepancy here about what we take mereology to be. Champollion is not "not committed to the assumption that the relation between John and his arm is mereological parthood" (Champollion 2010:41-42). In *Covert*, page 14, he says "the notion of mereological part must be distinguished from the intuitive notion of part, so that the leg of a table is not a mereological part of the table". That doesn't seem a desirable option on my understanding of mereology.

(42) Jack and Jill shampooed [3 dogs each_{ag}], each_{ag} with just two bottles of shampoo.

If all apparently non-narrow scope adnominal *each* can be handled this way, that makes a headache for data collection, but the theory is not challenged.

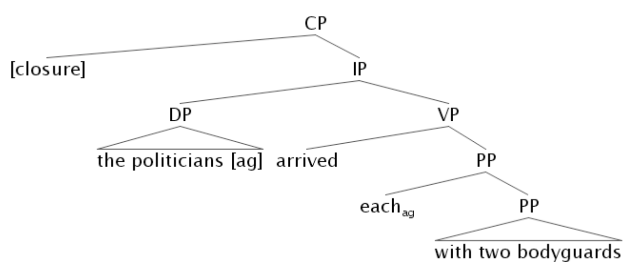
I've focused here on just two kinds of distributivity operators found in natural language. But there are others. *Each* is overt and it distributes over explicitly mentioned singularities, like Jack or Jill. But distributivity operators maybe covert, and they may distribute over pluralities (Part operators), occasions (*jeweils*) and times (*for* adverbials). And the elements distributed over may be supplied by context. Champollion offers a theory of these operators that not only gives their meanings but also aims to explain when and where the different types of distributors can be deployed.

Exercise

1. Provide the meaning of the sentence:

(43) The politicians arrived, each with two bodyguards.

Assume the syntactic structure below as well as the meaning of *with two bodyguards* given in (44) below (**comit** is from 'comitative'):



(44) *with two bodyguards* $\rightsquigarrow$ λe [**guards**(**comit**(e)) $\wedge$ |**comit**(e)| = 2]

2. Enumerate the challenges that arise in trying to apply the theory to the following example:

(45) The bartender danced every dance, each with a different young man.

Suggest a way to address some of these challenges by considering a simplified version of the example and providing a meaning for it.

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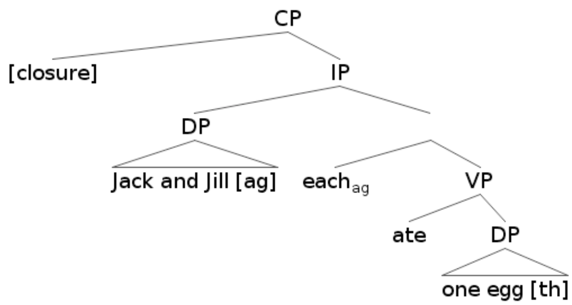
Overt → *Interaction*

Adverbial each

We are now ready to look into implementing *Overt* ideas about adnominal and adverbial *each* in the context of the *Interaction* system. We'll begin with adverbial *each*, whose *Overt* analysis is summarized below:

(46) *Jack and Jill each*$_{\text{ag}}$ *ate one egg* $\rightsquigarrow$
$\exists e[\mathbf{ag}(e){=}\mathbf{jack{+}jill} \wedge e \in {}^{*}\lambda e'\ [\exists z.\ \mathbf{egg}(z) \wedge \text{Atom}(\mathbf{ag}(e')) \wedge \mathbf{eat}(e') \wedge \mathbf{th}(e'){=}z)]]]$



Adverbial *each* is a VP modifier. So as a first step let's review the *Interaction* modifiers discussed earlier:

(47) *heavily* $\rightsquigarrow$ $\lambda V.\ \lambda f.\ V(\lambda e.[\mathbf{heavy}(e) \wedge f(e)])$

(48) *not* $\rightsquigarrow$ $\lambda V.\ \lambda f.\ \neg V(f)$

Recall that in *Interaction*, V is a variable over verb-type meanings and that verb meanings include the event-existential. So *not* adds material above the existential and *heavily* adds meaning below it. Looking back at (46), I notice that the event-existential comes at the very top of the formula, so I conclude that adverbial *each*$_{\text{ag}}$ should get a meaning like *heavily* but in place of '**heavy**(e)' we should have a sum-distributivity statement. This leads us to the following meaning:

(49) *each*$_{\text{ag}}$ $\rightsquigarrow$ $\lambda V.\ \lambda f.\ V(\lambda e\ [e \in {}^{*}\lambda e'.\mathbf{ag}(e') \wedge f(e)])$

Using (49) in conjunction with the meanings in (50)-(51) below and closing by applying to the set of all events, we get:

(50) *Jack and Jill*-[ag] $\rightsquigarrow$ $\lambda V.\ \lambda f.\ V(\lambda e[\mathbf{ag}(e) = \mathbf{jack{+}jill} \wedge f(e)])$

(51) *ate one egg* $\rightsquigarrow$ $\lambda f.\ \exists x[\mathbf{egg}(x) \wedge \exists e[\mathbf{eat}(e) \wedge \mathbf{th}(e) = x \wedge f(e)]]$

(52) $\exists x[\mathbf{egg}(x) \wedge \exists e[\mathbf{eat}(e) \wedge \mathbf{th}(e) = x \wedge e \in {}^{*}\lambda e'.[\mathbf{ag}(e') \wedge \mathbf{ag}(e) = \mathbf{jack{+}jill}]]]$

This is not right. We've lost an egg. The source of the problem is that *each* makes its contribution within the $f(e)$ conjunct in (51) and by that time, the one egg is already entered as the theme of the whole event. In other words, the object of *eat* falls outside the scope of the sum-distributivity operation, $e \in {}^*\lambda e'$.

We've shown that the particular attempt in (49) is a failure. I cautiously conclude that there is no way to implement a sum-distributive analysis of adverbial *each* in the *Interaction* system. While I find the exercise in (46)-(52) useful for understanding both *Overt* and *Interaction*, a more direct argument for this conclusion can be arrived at from negation. Consider the following lottery advice:[3]

> If you are thinking about playing but haven't yet picked your numbers, it might be useful to know that the most popular numbers, 90 and 88 haven't appeared in the draw for 154 and 151 days respectively, and 85, 1 and 55 have each not appeared for 150 days, so it could be their time to shine again.

In the final conjunct, *each* has scope over negation. Recall that one of the achievements of *Interaction* is to give negation scope over the event-existential. By transitivity of scope, in the example above, *each* takes scope over the event-existential. But sum-distributivity requires access to an open event predicate.

Let me summarize my conclusions. Sum-distributivity requires access to an open-event predicate. This means that an *Overt* style analysis of adverbial *each* requires it to be treated like a manner adverbial such as *heavily*. But doing that gives it very narrow scope. In *each ate one egg*, *one egg* is assigned scope above *each*. And assuming that negation scopes above the event-existential, *each* is necessarily assigned scope below negation. Empirically, *each* can take scope above an object quantifier and above negation. I conclude that a sum-distributive analysis of adverbial *each* is not viable within the *Interaction* system.

This is a strong conclusion and it's based on assumptions about negation and event semantics that could be challenged. The conclusion is that a sum-distributive analysis is not possible. That answers our main question. But this doesn't mean that no analysis is possible. I want to conclude with an *Interaction*-compatible proposal for adverbial *each*:

(53) *each*-[ag] $\rightsquigarrow$ $\lambda V.\ \lambda z.\ \lambda f.\ \forall y[y \preceq z \wedge |y|=1 \rightarrow V(\lambda e.\ \mathbf{ag}(e)=y \wedge f(e)])$

(54) *ate one egg*-[th] $\rightsquigarrow$ $\lambda f.\ \exists x[\mathbf{egg}(x) \wedge \exists e[\mathbf{eat}(e) \wedge \mathbf{th}(e) = x \wedge f(e)]]$

(55) *each*-[ag] *ate one egg* $\rightsquigarrow$

$$\lambda z.\ \lambda f.\ \forall y[y \preceq z \wedge |y|=1 \rightarrow \exists x[\mathbf{egg}(x) \wedge \exists e[\mathbf{eat}(e) \wedge \mathbf{th}(e) = x \wedge \mathbf{ag}(e)=y \wedge f(e)])$$

[3] http://www.superenalotto.net/news/will-13million-be-lucky-for-you.asp

(56) Jack and Jill each-[ag] ate one egg-[th] $\rightsquigarrow$

$$\forall y[y \preceq \mathbf{jack{+}jill} \wedge |y|{=}1 \rightarrow \exists x[\mathbf{egg}(x) \wedge \exists e[\mathbf{eat}(e) \wedge \mathbf{th}(e) = x \wedge \mathbf{ag}(e){=}y])$$

This proposal assumes that the [ag] thematic role head is combined with *each* not with *Jack and Jill*. This probably makes the most sense on a movement analysis of floated *each*. [References: Bobaljik?, Fitzpatrick?]

It is instructive to compare this proposal for adverbial *each* with the *Interaction* meaning for universal DP with agent role:

(57) *every robot*-[ag] $\rightsquigarrow$ $\lambda V.\ \lambda f.\ \forall x[\mathbf{robot}(x) \rightarrow V(\lambda e[\mathbf{ag}(e) = x \wedge f(e)])]$

(58) *each*-[ag] $\rightsquigarrow$ $\lambda V.\ \lambda z.\ \lambda f.\ \forall y[y \preceq z \wedge |y|{=}1 \rightarrow V(\lambda e.\ \mathbf{ag}(e){=}y \wedge f(e)])$

Exercise

Calculate the meaning of *Jack and Jill each wrote less than 3 poems* assuming the string in (59) and the meanings in (60)-(64):

(59) Jack and Jill λx [each-[ag] t_x] wrote less than 3 poems [th].

(60) *Jack and Jill* $\rightsquigarrow$ $\lambda P.\ P(\mathbf{jack{+}jill})$

(61) *less than 3 poems* $\rightsquigarrow$ $\lambda P.\ \neg\exists z\ [\mathbf{poems}(z) \wedge |z| \geq 3 \wedge P(z)]$

(62) *wrote* $\rightsquigarrow$ $\lambda f.\ \exists e[\mathbf{write}(e) \wedge f(e)]$

(63) *each*-[ag] $\rightsquigarrow$ $\lambda z.\ \lambda V.\ \lambda f.\ \forall y[y \preceq z \wedge |y|{=}1 \rightarrow V(\lambda e.\ \mathbf{ag}(e){=}y \wedge f(e)])$

(64) $t_x \rightsquigarrow x$

What truth values does this analysis predict for *Jack and Jill each wrote less than 3 poems* in (a) a situation where Jack wrote nothing and Jill wrote a total of 2 poems and (b) a situation where Jack wrote nothing and Jill wrote a total of 4 poems?

Calculate the meanings of:

(65) Jack and Jill λx [each-[ag] t_x] didn't leave.
(66) Jack and Jill λx didn't [each-[ag] t_x] leave.

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Adnominal *each*

In the sentence, *Jack and Jill ate one egg each*, adnominal *each* combines with the object *one egg*. To see how that might work *Interaction*ally, consider the *Overt* style meaning for *one egg*[th] *each* and the *Interaction* meaning for *one egg*:

(67) *one egg*[th] $each_{\mathrm{ag}}$ ⤳
$\lambda e.\ e \in {}^*\lambda e'[\mathrm{Atom}(\mathbf{ag}(e')) \wedge \exists z.\ \mathbf{egg}(z) \wedge \mathbf{th}(e') = z)]$ (*Overt*)

(68) *one egg*[th] ⤳ $\lambda V.\ \lambda f.\ \exists z[\mathbf{egg}(z) \wedge V(\lambda e[\mathbf{th}(e) = z \wedge f(e)])]$ (*Interaction*)

The '$f(e)$' conjunct in (68) is there to allow further information to be added. And the '$\lambda V.\ \lambda f$' is needed to allow application to a verb meaning to produce a verb meaning. Both will be necessary as well for *one egg*[th]*each*. And then (67) tells us what should come between '$\lambda V.\ \lambda f$' and '$f(e)$'. This leads to the following proposal for an *Interaction*al meaning for *one egg*[th] $each_{\mathrm{ag}}$:

(69) *one egg*[th] $each_{\mathrm{ag}}$ ⤳
$\lambda V.\ \lambda f.\ V(\lambda e.\ e \in {}^*\lambda e'[\mathrm{Atom}(\mathbf{ag}(e')) \wedge \exists z.\ \mathbf{egg}(z) \wedge \mathbf{th}(e') = z)] \wedge f(e))$

If we combine this meaning with that of *ate* in (70), we get (71):

(70) ate_{ag} ⤳ $\lambda f.\ \exists e.\ [\mathbf{eat}(e) \wedge f(e)]$

(71) *ate one egg*[th] $each_{\mathrm{ag}}$ ⤳
$\lambda f.\ \exists e.\ [\mathbf{eat}(e) \wedge e \in {}^*\lambda e'[\mathrm{Atom}(\mathbf{ag}(e')) \wedge \exists z.\ \mathbf{egg}(z) \wedge \mathbf{th}(e') = z)] \wedge f(e))$

Notice that the scopes are correct. The egg existential is inside the sum distributivity statement. If we now add the subject and closure we get what we had in *Overt*:

$\exists e.\ [\mathbf{eat}(e) \wedge e \in {}^*\lambda e'[\mathrm{Atom}(\mathbf{ag}(e')) \wedge \exists z.\ \mathbf{egg}(z) \wedge \mathbf{th}(e') = z)] \wedge \mathbf{ag}(e) = \mathbf{jack+jill})$

Unlike with adverbial *each*, in this case, the egg existential correctly falls within the distributivity statement. This is a direct result of the meaning we assigned in (69). Is it now possible to give a meaning for $each_{\mathrm{ag}}$ that when applied to the meaning of *one egg* in (68) will give us (69)? (68) is complicated, however consider what happens when we apply essentially type shifting operations:

(72) $\lambda V.\ \lambda f.\ \exists z[\mathbf{egg}(z) \wedge V(\lambda e[\mathbf{th}(e) = z \wedge f(e)])]]\ (\lambda f.\ f(e'))$
$= \lambda f.\ \exists z[\mathbf{egg}(z) \wedge [\mathbf{th}(e') = z \wedge f(e')])]$

(73) $\lambda f.\ \exists z[\mathbf{egg}(z) \wedge [\mathbf{th}(e') = z \wedge f(e')])]\ (\lambda e.\mathbf{true})$
$= \exists z[\mathbf{egg}(z) \wedge \mathbf{th}(e') = z]$

We've gotten to the part of (69) that should come from the quantifier *one egg*. This leads to the following proposal for adnominal *each*:

(74) $\text{each}_{\text{ag}} \rightsquigarrow$

$$\lambda Q.\ \lambda V.\ \lambda f.\ \ V(\lambda e.\ e \in {*}\lambda e'\ [\text{Atom}(\mathbf{ag}(e')) \wedge Q(\lambda f.\ f(e'))(\lambda e.\mathbf{true}\ )] \wedge\ f(e))$$

Our conclusion then is that it is indeed possible to implement the *Overt* view of adnominal *each* in the *Interaction* framework.

Downward Entailing Contexts

Having imported adnominal *each* into the *Interaction* framework, we can now address questions we couldn't have addressed in either *Overt* or *Interaction* by itself. In particular, what happens when adnominal *each* co-occurs with negation? Notice that in our meaning in (74) the $e \in {*}\lambda e'$ statement is in the scope of V. We want that so that it will end up under the event existential as in (71). Negation, recall, comes above the event existential. We therefore predict that adnominal *each* will always take scope below negation. The two examples below test that prediction:

(75) Those postmen were fired because they didn't deliver at least 3 boxes each to the Prime Minister's office.

(76) Those students didn't hand in at least 3 homeworks each.

Here are three observations.

(a) On a predicted *not* > *each* reading, these sentences would be true if some of the postmen delivered all their boxes and if some of the students handed in all of their homeworks. But I tend to hear these as saying that all the postmen/students 'messed up'. It seems like we're getting the unpredicted *each* > *not* interpretation.

(b) Without *at least,* the predicted *not* > *each* reading is more salient.

(c) Consider this paraphrase of the unpredicted *each* > *not* reading of the part of (75) under *because*:

(77) For each of the postmen, p, there were at least 3 boxes B: p did not deliver B.

If the quantification in (77) is totally unrestricted, it can't be a plausible paraphrase of (75). There are always three boxes, somewhere, that a given postman doesn't deliver. And it isn't enough to restrict quantification to relevant boxes. Postman 1 doesn't deliver many relevant boxes – the ones on postman 2's truck. So, *boxes* needs to be restricted as follows:

(78) For each of the postman, *p*, there were at least 3 boxes B *that p was supposed to deliver*: *p* did not deliver B.

That means that in (75), the host of *each* is quite specific. That's a bit surprising given that adnominal *each* doesn't generally allow a specific host.

Exercise

This is more a squib than an exercise. Consider the following example:

(79) Oil India Chairman S.K. Srivastava and finance director Rupshikha Saikia Borah didn't answer two calls each to their mobile phones yesterday seeking comment. Sandesara Group Chairman Nitin Sandesara didn't respond to an e-mail and phone call to his office.

The first sentence is another example of an unpredicted *each* > *not* reading. Notice that the second sentence makes sense assuming this reading of the first sentence.

i. Produce a simplified version of the first sentence in (79) by choosing a simpler plural subject, omitting the modifiers after *each* and leaving off the negation. Produce an *Overt* style formula that captures the meaning of your simplified sentence.
ii. Add back in some or all the modifiers following *each*. Produce an *Overt* analysis of the result.
iii. Add negation to your (i) sentence. Provide its meaning, as much as possible in *Overt* style.
iv. Add the modifiers to the negated sentence in (iii). Analyze.
v. Discuss the restrictions on the noun *call*, along the lines of the observation in (c) above. Are these presuppositions? How do they figure in the negated case?

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In the challenging examples in (75)-(76), negation appears to take scope below *each* – something unpredicted under the proposed *Overt+Interaction* analysis in (74). There is another kind of example that works like that, but which uses monotone decreasing modified numerals. Here's an example:

(80) Jack and Jill wrote less than 3 poems each.

There is a salient reading of this example on which it is truth conditionally equivalent to:

(81) Jack wrote less than 3 poems and Jill wrote less than 3 poems.

I've tried hard to see a way to handle this example in an *Overt* friendly way. I have a possible suggestion, but before giving that, I want to mention two observations about the example that will hopefully allow you to avoid pitfalls that I fell into. First, there seems to be some sort of implication from (80) that Jack and Jill both wrote poems. I don't think this should be part of the truth conditions. Here's a scenario that makes that palpable. Suppose a group of children have eaten some cherries and we've just learned that there may be a small amount of dangerous chemical on the cherries. We call the doctor, who assures us:

(82) If the children ate less than 3 cherries each, they will be ok. Otherwise, bring them in immediately.

The 'otherwise' clause doesn't get triggered by the discovery that some of the children didn't eat any cherries. In other words, the antecedent of the conditional is compatible with a non-cherry-eating child.

Assuming now that *Jack wrote less than 3 poems* is true if Jack wrote nothing, consider the following two scenarios:

[0/4] Jack wrote nothing. Jill wrote 4 poems.
[0/2] Jack wrote nothing. Jill wrote a total of 2 poems.

The sentence in (80) is intuitively false in the [0/4] scenario and intuitively true in the [0/2] scenario. This means that any formula that starts with '$\exists e.\ \mathbf{ag}(e) = \mathbf{jack{+}jill} \wedge \mathbf{write}(e)$' will not capture the meaning of (80). It will be false in both scenarios. It also means that simply having a wide-scope negation probably won't work. The non-negated *Jack and Jill wrote at least 3 poems each* doesn't discriminate between [0/2] and [0/4], so its negation doesn't either. I tried various versions of pulling out just the *less than 3*, they didn't work either.

I haven't seen this type of example discussed. Zimmermann(2002: page 27,fn9) comes close when he mentions '*genau n* NP' as a possible problem for his claim that "Adnominal *jeweils* requires a predicate-denoting expression as its first argument." It seems to me that (80) would not work in Dotlačil(2012)'s system as presented, but that that has more to do with choices about adhering to Zimmermann's predicate claim, then about the structure of the theory. I haven't read Cable(2004) or Zimmermann(2002) or Blaheta(2003).

A possible avenue to explore picks up an idea in Magri(2014), according to which definite plurals are in fact existential and this reality comes through in downward entailing contexts where implicatures that normally strengthen plurals fail to arise. To see that this might be promising, notice that the meaning of (80) is captured by either of the formulas below:

(83) $\neg\exists z\ [\mathbf{poems}(z) \wedge |z| \geq 3 \wedge \exists y\ [y \preceq \mathbf{jack{+}jill} \wedge \exists e\ [\mathbf{ag}(e) = y \wedge \mathbf{write}(e) \wedge e \in {}^*\lambda e'[\mathrm{Atom}(\mathbf{ag}(e') \wedge \mathbf{th}(e') = z]]]]$

(84) $\neg\exists \mathrm{n}\ \mathrm{n}\geq 3\ \exists y\ [y \preceq \mathbf{jack{+}jill} \wedge \exists e\ [\mathbf{ag}(e) = y \wedge \mathbf{write}(e) \wedge e \in {}^*\lambda e'[\mathrm{Atom}(\mathbf{ag}(e') \wedge \exists z\ [\mathbf{poems}(z) \wedge |z| = \mathrm{n} \wedge \mathbf{th}(e') = z]]]]$

The idea would be that *less than 3 poems* or just *less than 3* takes inverse scope over the whole sentence.

The Magri-move opens the way for a possible solution to the unpredicted *each* > *not* readings discussed earlier. As an intermediate step, consider (85) and the formula in (86):

(85) Jack and Jill didn't hand in at least 3 homework each.

(86) $\neg\exists y\, [y \preceq \textbf{jack+jill} \ \wedge \exists e\, [\textbf{ag}(e) = y \wedge \textbf{hand-in}(e) \wedge e \in {}^*\lambda e'[\text{Atom}(\textbf{ag}(e') \wedge \exists z\, [\textbf{homeworks}(z) \wedge |z| \geq 3 \wedge \textbf{th}(e') = z]]]]$

In (86), negation takes wide scope as required by our *Interaction+Overt* theory and the subject is understood Magri-wise as a plural existential. This explains the apparent wide scope of *each* ($\neg\exists \equiv \forall\neg$). But (86) is not yet the meaning of (85). (85) could be true if Jack and Jill each handed in 7 out of 10 homeworks but (86) excludes that possibility. But now consider our earlier observations about specificity. (85) must be understood to be about specific homeworks, the ones that Jack and Jill were required to submit. Perhaps once that requirement is added to (86), the result will be the meaning of (85). Suppose we add that specificity in via a kind of choice function. In (87), I define a space of choice functions designed to capture the intuitive restriction to required homeworks. And then in (88), I have a modified version of (86):

(87) HWK is the space of partial functions from events and sets such that for any k in HWK and for any event e and set P in the domain of k:

$k(e,P) = y \rightarrow P(y)$ and y is among the homeworks required of the agents of e

(88) $\exists k\ \ k \in \text{HWK} \wedge \neg\exists y\, [y \preceq \textbf{jack+jill} \ \wedge \exists e\, [\textbf{ag}(e) = y \wedge \textbf{hand-in}(e) \wedge e \in {}^*\lambda e'[\text{Atom}(\textbf{ag}(e') \wedge \textbf{th}(e') = k(e', \lambda x.[\textbf{homeworks}(x) \wedge |x| \geq 3])]$

The meaning in (88) entails that:

(89) You can assign required-homework-trilogies to Jack and to Jill, such that Jack didn't hand in his trilogy and Jill didn't hand in hers.

It is interesting to trace the contribution of *each* to the meaning in (88). As noted above the apparent universal over negation is in fact coming from the treatment of definite plurals and not from *each.* The contribution of *each* comes at the last line. k assigns required-homeworks to agents, per (87), and (88) requires these to be atomic-agents. So supposing that Jack and Jill each skipped three homeworks, but they handed in all 8 of the required group-homeworks the sentence remains true. Group-homeworks play no role here because of the *each*.

The analysis is in (88) is surprising, as both adnominal *each* and *at least* are known to be allergic to specific and/or wide-scope indefinite readings.

Exercise

The following sentences need to be read a few times before they sound noncontradictory:

Jack and Jill wrote over 30 poems together and they wrote less than 3 poems each.

Jack and Jill wrote over 30 poems together and they each wrote less than 3 poems.

Is that to do with contextual covers? [see *Covert*/*Overt*] the possibility of *each* bearing contrastive stress?

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for adverbials

Durational *for* adverbials are discussed in *Covert* and in *Interaction*. The two papers consider different kinds of facts pertaining to these adverbials and present different meanings for these adverbials. In this section, I'll compare the two analyses and conclude that they are incompatible. I'll end with some brief remarks about the *Covert* analysis of *for* adverbials. These will be about aspects of the analysis that puzzled me but that don't have directly to do with integrating the two accounts.

The empirical focus of *Covert* is *for* adverbials that modify verb phrases with indefinite singular objects. The following pair illustrates the pattern of data Champollion is interested in:

(90) ??John found a flea on his dog for a month. (Zucchi and White 2001)
(91) The patient took two pills for a month and then went back to one pill.

Example (91) "is based on observations in Moltmann (1991). Out of the blue, examples like these are odd because they suggest that the same flea is found repeatedly, the same pills are taken repeatedly, and so on. But context can improve such examples by making covariation of the indefinite or numeral possible. Thus (91) is acceptable in a context where the patient's daily intake is salient (in a hospital, for example). It does not require any pill to be taken more than once, so we have covariation." Switching from a singular indefinite to a bare plural object,

(92) John found fleas on his dog for a month. (Dowty 1979)

removes the entailment that a single flea has been found repeatedly

Interaction is concerned with the fact that *for* adverbials can take scope above negation. *Jack didn't laugh for two hours* has a reading according to which Jack refrained from laughing for two hours.

The meanings proposed in the two papers for the expression *for an hour* are given below.

(93) $\lambda V.\ \lambda f.\ \exists t[\textbf{hour}(t) = 1 \wedge t \subseteq t_{\text{ref}} \wedge \forall t'\ [t' \subseteq t \rightarrow V(\lambda e.\ [f(e) \wedge\ \tau(e) = t'])]]$

(94) a. $\lambda P.\ \lambda e$: $\text{ATELIC}(P)$. $P(e) \wedge$ hours$(\tau(e)) = 1$. (*Covert*)

b. $\text{ATELIC}(P) \coloneqq$
$\forall e.\ P(e) \rightarrow [e \in {}^*\lambda e'\ [P(e') \wedge \tau(e')$ is very short relative to an hour$]]$

The two meanings are of different types. That by itself is not a problem. Although there may be specific issues with the meaning in (94) (see Exercise below), in general we know how to convert event-modifier meanings into *Interaction*al meanings. The crucial difference between the meanings is that in (93), the quantifier '$\forall t'$' scopes above 'V', meaning that it takes the event existential in its scope, while the meaning in (94) relies on having access to an open event predicate. Let's review how the data and analysis lead to these differences. In the case of (93), the adverbial gets scope above the event existential. (93) allows us to assign truth conditions to *Jack didn't laugh for an hour* according to which for every subinterval of the hour in question, there was no event of Jack laughing. This correctly captures the *for* > *not* reading. The selling point of this analysis is that it doesn't require the occurrence of an event of no-laughing, what you might call a 'negative event'. To achieve this, (93) has to involve a quantifier, $\forall t'$, that scopes above V and thus above the event-existential. Turning to (94), here the action is below the event-existential. (94) leads to truth conditions for (90) that entail:

(95) $\exists e.\ \textbf{find}(e) \wedge \textbf{flea}(\textbf{th}(e)) \wedge$ months$(\tau(e)) = 1$

The event quantified in (95) could be plural – it could be the sum of several findings, but crucially, the theme of all those events is a single flea. This leads to the desired problematic entailment that a single flea was repeatedly found. If the *Interaction* meaning were used here instead we wouldn't get the single flea entailment. Instead, our meaning would entail the presence of a large number of subintervals in which potentially different fleas were found. Both accounts lead to strange meanings, so both predict the oddness of (90). Determining the right analysis is not our goal here. We're taking the *Covert* view of the flea facts for granted and our conclusion is that *Interaction* wants *for* adverbials to take scope above the event-existential, *Covert* needs it to be below the event-existential and so they are incompatible.

Exercise

i. Using the meaning of *heavily* as a guide, provide an *Interaction* type meaning for *for an hour* based on the following simplification of (94):

(96) $\lambda P.\ \lambda e.\ P(e) \wedge$ hours$(\tau(e)) = 1 \wedge [e \in {}^*\lambda e'\ [P(e') \wedge \tau(e')$ is very short relative to an hour$]]$

'P' occurs twice in (96), which means you'll likely want 'V' to occur twice in your meaning. 'V' will contain an '$f(e)$' conjunct and you may only want one such conjunct in your final meaning. You can eliminate one of them by applying a kind of type shift, along the lines of:

$$\lambda f.\ \exists e\ [\textbf{find}(e) \wedge f(e)]\ (\lambda e\ e = e') = \ \exists e\ [\textbf{find}(e) \wedge e = e']\ =\ \textbf{find}(e')$$

ii. Discuss the possibility of redoing the exercise in (i) but without the simplification, in other words, preserving the presuppositional meaning given in (94).

iii. Modify the *Interaction* meaning in (93), so that it includes the *Covert* idea of sum distribution. More specifically replace the universal quantification over intervals with a statement of the form '$t \in {}^*\lambda t'$…...'. How does this meaning compare to the one in (93)?

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Interaction promises an event semantics that can account for negation and quantifiers in a more or less standard way and it promises an analysis of *for* adverbials. This means that after all is said and done, we should be able to accommodate quantifiers in the scope of *for* adverbials. I want to briefly consider some of the issues that will have to be dealt with.

So far, we've discussed one such case, *find a flea for a month*, in which a singular indefinite occurs within the scope of a *for* adverbial. Recall, that on the *Covert* analysis this leads to the entailment that:

(97) $\exists e.\ \textbf{find}(e) \wedge \textbf{flea}(\textbf{th}(e)) \wedge \text{months}(\tau(e)) = 1$

which leads to the desired multiply-found flea entailment. If the singular indefinite is replaced by a bare-plural, as in Dowty's (92) above, the entailment changes to (98).

(98) $\exists e.\ \textbf{find}(e) \wedge \textbf{fleas}(\textbf{th}(e)) \wedge \text{months}(\tau(e)) = 1$

Since multiple findings could yield a plurality of fleas, we correctly avoid the multiply-found flea entailment. Champollion assumes that the literal meaning of *fleas* "is essentially *one or more fleas*". In that case, it is surprising that unlike Dowty's example, (99) below is odd.

(99) ??Jack found one or more fleas on his dog for a month

Champollion's use of the expression "literal meaning" suggests a possible pragmatic difference between bare plural *fleas* and *one or more fleas*. One might imagine a pragmatic account along the following lines, inspired by Schwarz(2014) and references therein. *One or more fleas* competes with *exactly 1 flea* and *more than one flea*. That competition leads to an uncertainty inference according to which the speaker doesn't know if it was just one flea or more than one flea that was found. But given the ATELIC presupposition that means the speaker is entertaining the possibility of a multiply found flea. This reasoning extends to:

(100) ??Jack found more than two fleas on his dog for a month

Assuming no multiply found fleas and that the ATELIC presupposition is met, there would have to be a total of more than two fleas found, since there would have to be two fleas for each short interval within the month – so that would lead to 2 x n fleas, for n short intervals. If *more than two* suggests uncertainty about whether the total is 3 or not, then the speaker must be allowing for multiply found fleas.

If such an idea can be made to work, it would be interesting to then consider a pragmatic account of the singular indefinite, which might open up new possibilities for the semantics of *for* adverbials – possibly one compatible with the negation facts[4].

Downward entailing quantifiers are another kind of quantifier that would come within the purview of an *Interaction*al account of *for* adverbials. Consider (101) below, which also seems odd to me:

(101) ??Jack ate less than 3 eggs for an hour.

It's hard to see what the problem is here on either of the analyses presented at the beginning of this section ((93), (94)). Suppose we're discussing the Jack and Jill breakfast meeting in which Jack had one egg. Then within that meeting, there is an hour long interval in which Jack ate less than 3 eggs and the same is true for every subinterval of that interval. Here I'm assuming the *Interaction* view, according to which the object quantifier scopes above the event existential. It is also true that the event in which Jack ate his one egg, is an event in which less than 3 eggs are consumed and which consists of shorter events in which less than 3 eggs are consumed. In this case too, it might be worth considering a new-pragmatics account that allows us to bring in exact amounts.

Summarizing now, the *Covert* analysis offers an account of examples with two kinds of objects. Once we upgrade to an *Interaction* semantics, the full range of quantificational objects should come into view. It's not clear that the sum-distributive approach of *Covert* will be able to keep up.

An attractive and novel aspect of the *Covert* analysis of *for* adverbials lies in its treatment of the context dependence of examples like (102) repeated from above:

(102) The patient took two pills for a month and then went back to one pill.

The account relies on the presence of a covert, context dependent, distributivity operator, called a *Part*-operator after Schwarzschild(1996). The Part-operator combines with the phrase *took two pills* to create a predicate that satisfies ATELIC but without implicating a repeatedly swallowed pill. The Part-operator is modeled on adverbial *each*. Above we

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[4] The following, for example, is flat out contradictory:

(i) ∃t Jack wrote exactly one letter at t and t consists of smaller non-overlapping t' such that Jack wrote exactly one letter at t'.

A pragmatic story that gets us from *a flea* to *exactly one flea* will lead into (i).

concluded that adverbial *each* needs an *Interaction* meaning whereby it scopes above the event existential. If the Part-operator likewise needs to takes scope above the event existential, it will no longer be able to play the role required in (102). The ATELIC presupposition characterizes a predicate with an open event argument.

Covert *specific issues*

The atelicity presupposition

The *Covert* meaning includes an atelicity presupposition repeated below:

(103) ATELIC(P) ≔
$$\forall e.\ P(e) \rightarrow [e \in {}^*\lambda e' \ [P(e') \wedge \tau(e') \text{ is very short relative to an hour}]]$$

The presupposition has a universal quantifier in it that I find puzzling. Let me explain why. On the *Covert* analysis, the sentence:

(104) The snake ate eggs for an hour.

describes an hour long event in which eggs are consumed, and it requires that that event be the sum of temporally shorter events in which one or more eggs is consumed. The analysis follows the lead of Kratzer(2007), however Kratzer's account makes no mention of temporal brevity. The following scenario shows the advantage of Champollion's improvement. Imagine we watch a snake open its mouth very wide and four robin eggs roll in. We then watch, over the course of an hour, as the eggs slowly make their way down the length of the snake. Sentence (104) sounds like an infelicitous description of that scenario[5]. This follows on Champollion's account, because we can't find temporally shorter subevents in which eggs are consumed. But without the temporal restriction, we would have a problem – because the big event is itself the sum of several egg eatings, one for each robin egg. So we would incorrectly predict this to be felicitous.

But now this advantage for Champollion's account seems problematic. We have found an event, the snake's egg eating, which satisfies the predicate *eat eggs* but which doesn't satisfy the sum-distributive requirement in the consequent of (103). Given that (103) is universal, it follows that *eat eggs* is not ATELIC. So we rule out *Jack ate eggs for an hour* even when he ate them one at time.

This type of problem also seems to arise quite generally from bare plurals. Suppose we agree with those who say that a bare plural like *letters* is true of a single letter. In that case, an event in which Jack wrote one letter in an hour, satisfies the predicate *write letters* but that event isn't composed of smaller events in which a letter is written. So *write letters* is not ATELIC.

[5] At least as infelicitous as *the snake ate an egg for an hour* would be if there was just one large egg going down the pipe.

Exercise: mereology again

This exercise is a kind of follow up to our earlier discussion of example (40) and mereology. Assume the following simplified *Covert* meaning of *for an hour*.

(105) $\lambda P.\ \lambda e.\ P(e) \wedge \text{hours}(\tau(e)) = 1 \wedge [e \in {}^*\lambda e'\ [P(e') \wedge \tau(e')$ is very short relative to an hour]]

The examples in (106) and (107) below are odd. Does the analysis in (105) predict this? For (106), assume a Pope's crown scenario in which the crown itself is constructed out of smaller crowns (Wiggins 1980). Jack makes a small crown, then another, then he solders them together, then another small one etc. Example (107) is modeled on one in L. Carlson(1981)'s discussion of indefinites in the scope of atelic adverbials.[6]

(106) $^?$Jack constructed a crown for an hour.
(107) $^?$Jack swept a small area for an hour.

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Conclusion

i. When we move to an *Interaction* framework, adverbial *each* can't be handled in the *Overt* way. It ends up getting obligatory narrow scope with respect to quantifiers and negation, contrary to the facts. An *Interaction*al meaning for adverbial *each* was proposed. But it's not a sum-distributive operator like in *Overt.*

ii. As far as the facts discussed in *Overt* are concerned, when we move to an *Interaction* framework, adnominal *each* <u>can</u> be handled in the *Overt* way. However, when we introduce *Interaction* type facts, negation and various quantifiers acceptable with *each*, we stumble. Two ingredients for progress were suggested: (a) adopt Magri's idea that plural definites are in truth existential. (b) allow for some type of wide-scope indefinite mechanism for the host of *each*.

iii. Durational *for* adverbials are discussed in *Interaction* and in *Covert*. The theoretical desiderata of the two papers appear incompatible. Like with adverbial *each*, they disagree about scope relative to the event existential. It might be worth revisiting the question of indefinites (and other quantifiers) under *for* adverbials in light of new work on the pragmatics of numerals.

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[6] Carlson(1981:61 (38))'s example was:

(38) The man cleaned up a large area all day long.

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