DISTANCE DISTRIBUTIVE EACH

Robert Henderson

1 INTRODUCTION

Some English sentences are ambiguous between collective and distributive readings.

(1) John and Mary wrote a paper.
   a. =John wrote a paper and Mary wrote a paper.
   b. =John and Mary wrote a paper together.

But such sentences are not always ambiguous, distance distributive (DD)-*each* forces the distributive reading.

(2) John and Mary wrote a paper each.

More interestingly, it also constrains the denotation of the subject and the object.

(3) a. *Most professors wrote a book each.
   b. *The professors wrote most books each.

The following analysis develops an account of these facts and others in a dynamic framework. The central idea is that DD-*each* needs an associate that introduces a free variable. DD-*each* then imposes a constraint that requires this variable to be evaluated with respect to a set of auxiliary functions that must all survive into the output.

After detailing the theoretical background, the analysis begins in §2. I show that DD-*each* needs to be functionally dependent, and that distributive predication can satisfy this constraint. §2.3 then builds an account to explain which quantifiers DD-*each* can distribute over. I will show that only those quantifiers that allow all of their auxiliary functions to survive into the output can occur with DD-*each*. In §3 my proposal will be compared to other approaches to distance distributivity in the literature. §4 resumes and considers areas for future work.

1.1 THEORETICAL BACKGROUND

The analysis I develop will take place in a general dynamic framework approximating those of File Change Semantics/Discourse Representation Theory. We interpret a File ϕ, and the content of an utterance is how it changes the content of a File. Each File has a domain and a set of conditions. The domain of a File ϕ, Dom(ϕ), is a set of indices, and the conditions of a File ϕ, C(ϕ), is a set of formula, which place conditions on the domain. We can have complex files, and we will see that the effect of quantification and distributive predication is to introduce auxiliary Files, which are a part of a main File.

We interpret Files with respect to a model, which has all the things we expect a model to have, like a domain of entities and an interpretation function that assigns extensions to predicates. I want to focus on the set of (partial) assignment functions from variables to entities because assignment functions are crucial for our definition of truth.

(4) Let G be the set of assignment functions given by a model M.
   a. ϕ is true iff there is a $g \in G$ that satisfies ϕ.
   b. g satisfies ϕ iff for every $x_n \in Dom(\phi)$, $g(x_n)$ meets the conditions in ϕ relative to M.

This is our basic theoretical model. Any new notions or embellishments will be explained as they are introduced in the analysis.

2 THE ANALYSIS

2.1 DISTRIBUTIVE PREDICATION

I want to analyze distributive predication as universal quantification over subparts of a plural entity. This means that we need to understand how to treat universal quantification first. In accordance with FCS/DRT and many others, I take a universal quantifier to construct tripartite file with a restrictor and nuclear scope.

(5) Every man lifted the piano.
   a. $[[x_1 : man(x_1)]_{\phi'} \forall_1 [lifted\ the\ piano(x_1)]_{\phi''}]_{\phi}$

The idea is that every extension of the input assignment function that satisfies the restrictor needs to have an extension that satisfies the nuclear scope.

(6) g satisfies ϕ iff every extension g_1 on x_1 that satisfies ϕ' makes ϕ'' true.

Now we need to know what it means for g_1 to make ϕ'' true.

(7) ϕ'' is true relative to g_1 iff there is an extension g'_1 that satisfies ϕ'' in M.

Now we need to extend this analysis to cases of distributive predication. Remember that sentences like that in (8) have both a distributive and a collective reading.

(8) John and Mary lifted the piano.
   a. =John lifted the piano and Mary lifted the piano.
   b. =John and Mary lifted the piano together.

I will following DRT in assuming that conjoined atomic entities can be summed into a plural discourse referent, namely $x_1 = John \oplus Mary$. Under the collective reading we get a simple file with a plural discourse referent.

(9) $[lifted\ the\ piano(x_1)]_\phi$ where $x_1 = John \oplus Mary$

In contrast, distributive predication results in a familiar tripartite complex file.

(10) $[[x_1]_{\phi'} \forall_1\ [lifted\ the\ piano(x_1)]_{\phi''}]_\phi$

The main difference is that the restrictor does not introduce a domain condition, instead it is a plural entity. This means that distributive predication must introduce a set of auxiliary functions in a different way than universal quantification. I propose it introduces a maximal set of subpart extensions.

(11) G_n is a maximal set of subpart extensions g of x_n iff $\forall g_n \in G_n$, g_n extends g relative to x_n and for each $a \Pi x$ there is an $g_n = a$ and every two functions $g_n, g'_n \in G_n,\ g_n(x_n) \neq g'_n(x_n)$.

Now we can define satisfaction for (10).

(12) g satisfies ϕ iff every subpart extension g_1 of g on x_1 makes ϕ'' true.

(13) ϕ'' is true relative to g_1 iff there is an extension g'_1 that satisfies ϕ'' in M.

Thus, *John and Mary (DIST) lifted the table* is true just in case each subpart of the plural entity *John and Mary* lifted the table, which is what we want.

2.2 FUNCTIONAL DEPENDENCE

Farkas (2002) makes a strong case that a D° element can place conditions on the properties of the functions that value the variable introduced by that D° element. For example, she shows that the reduplicated indefinite *egy-egy* in Hungarian requires that it be functionally dependent on another variable, namely it must be in the scope of an operator that creates a set of functions that make the operator

variable cover its value set. In this section I will show that DD-*each* requires the variable it associates with to be dependent in this same fashion. First we will see that the D° DD-*each* associates with must introduce a free discourse referent, that is, it must not be anaphorically bound or bound in a complex file. DD-*each* then imposes the dependency constraint on this free variable, which will account for why certain indefinites, like *a certain*, cannot easily introduce variables associated with DD-*each*.

There are two pieces of evidence that DD-*each* needs to associate with a free variable that it is incapable of introducing itself. First notice that DD-*each* requires a DP associate, unlike floating quantifier *each*.

(14) a. The students each danced.
b. *The students danced each.

We can make sense of the pattern in (14) if DD-*each* requires its associate to introduce a variable. In (14b) there is no such variable because there is no direct object.

Similarly, DD-*each* is ungrammatical with bare plural objects.

(15) a. The students each built sandcastles.
b. *The students built sandcastles each.

van Geenhoven (1998) analyzes bare plural objects as incorporated nominals. If this analysis holds, then we have an explanation for why DD-*each* is ungrammatical in (15b). The problem is that incorporated nominals do not introduce discourse referents, making DD-*each* unavailable.

I want to argue that the reason DD-*each* requires its associate to introduce a discourse referent is that it carries with it a functional constraint that only makes sense if there is a variable it can apply to. Specifically, DD-*each* imposes the Dependency Constraint on the variable its associate introduces.

(16) Dependency Constraint (Farkas, 2002)
The variable x_j introduced by a dependent D must be evaluated by functions in a set G_i where $i \neq j$.[1]

The result is that the indefinite in the following sentence must be evaluated by functions that are subpart extensions on the plural entity in subject position.

(17) The students$_i$ ate a pizza$_j$ each.

[1]We consider more closely the Dependency Constraint and the extent it enfoces covariation in §2.3.1

Example (17) will be satisfied just in case every function in the set of subpart extensions of x_i has an extension in G_i on x_j that makes the nuclear scope true. Crucially, the indefinite cannot be interpreted with respect to the input function, giving us the reading where there is a single pizza that the students each ate. The problem is not plausibility, indefinite associates of DD-*each* cannot have wide scope.

(18) a. *The students read a book each, namely *War and Peace*.
b. *The students saw a logician each, namely Kripke.

We can explain the lack of wide scope readings for plain indefinites with the dependency constraint, but we can also account for why DD-*each* is bad with *a certain*.

(19) *The students$_i$ read a certain book$_j$ each.

Although I will not go into the details of her solution, Farkas (2002) shows that *a certain* cannot be interpreted dependently if the variable it introduces is given a random value. This means that (19) is bad because x_j is forced to be dependent by DD-*each*, yet the value given to x_j is not identifiable in an accessible context. The situation improves if we satisfy the output constraint against non-random assignment Farkas identifies.

(20) John and Bill were trying to remember a certain date each, namely his wife's birthday.

(21) The students were asked to write about their favorite works by Emily Dickenson.
a. They chose a certain poem each and analyzed it.

It is clear then that the Dependency Constraint introduced by DD-*each* is a general property. Variables that are associated with DD-*each* cannot be interpreted with respect to the input function. In the case of *a certain*, this is an unacceptable situation unless we can satisfy the output constraint that allows it to be dependent, which is precisely what we would predict.

Now that we know that DD-*each* introduces a functional constraint that requires the variable it associates with to be interpreted dependently, we can understand why definite and quantification D° associates are ungrammatical with DD-*each*. The critical point is that the variable DD-*each* associates with must be allowed to covary, that is, it cannot be bound or get its interpretation anaphorically. Let's consider the second case first. Notice that names, definites, and pronouns cannot be associates of DD-*each*.

(22) a. *The students read the book each.

b. *The students read *War and Peace* each.
c. *The students read them each.

The problem in these cases is that the variable introduced by the direct object cannot be interpreted dependently because it is valued elsewhere, and so cannot covary. We run into a similar problem when we consider certain quantification associates of DD-*each*. Note that we cannot have unambiguously quantificational DPs, including proportional quantifiers as DD-*each* associates. Numerical and cardinal quantifiers are fine.

(23) a. *The students read every book each.
b. *The students read all the books each.
c. *The students read most books each.

(24) a. The students read 3 books each.
b. The students read at least 3 books each.
c. The students read a few books each.
d. The students read many books each.

I want to pursue a solution along the lines of Kamp and Reyle (1993). The quantifiers in (23) are bad with DD-*each* because they do not introduce a free variable that can covary. In DRT this variable would be bound in a duplex condition, while in the approach taken here, the problem is that the variable introduced by the quantifier is embedded in a complex file and coerced into helping define a set of auxiliary functions, so it cannot be bound. The reason numerical and proportional quantifiers are licit is that they introduce a free discourse referent (Kamp and Reyle, 1993). The following DRS shows that we can take these quantifiers to introduce a free variable in the main DRS (here γ), while we perform abstraction over another variable to compute the cardinality of γ.

(25) Few mad scientists left.

a.

γ	
$\gamma = \Sigma x$:	x
	mad scientist(x)
	left(x)
$\lvert\gamma\rvert \leq$ few	

Since γ is free, it can be coerced into being dependent by DD-*each*. Taking the distinction Kamp makes seriously, we can fully explain which D°s DD-*each* can associate with. We saw that DD-*each* requires its associate to introduce a variable, ruling out intransitive verbs and bare plurals. We have also seen that

this variable must be free, which explains why definites and certain quantifiers are illicit associates, even though numerical and cardinal quantifiers are grammatical. The reason is that variables bound anaphorically or in a complex file cannot covary. The covariation is imposed by DD-*each* through the Dependency Constraint, which forces the associate of DD-*each* to be in the scope of a variable that is made to cover its value set. We saw that this constraint explains why *a certain* cannot associate with DD-*each* unless the discourse satisfies the output constraint allowing it to be dependent.

In the next section I want to build an analysis for which D°s DD-*each* can distribute over, but first note that there is one case that we do not need to worry about; the Dependency Constraint takes care of it.

(26) a. *John read a book each.
b. *The child read a book each.
c. *A child read a book each.

Example (26) shows that singular NPs, whether definite or indefinite, cannot appear with DD-*each*. We can understand this restriction immediately when we notice that the Dependency Constraint forces the variable introduced by the indefinite object to be interpreted with respect to a set of auxiliary functions extended on a variable. Thus far we have seen that only quantifiers and plural discourse referent under distributive readings introduce a set of functions that cover its value set (or in the case of plurals, a set of subpart extensions that cover a plural entity). This means that the variable associates of DD-*each* in (26a-c) cannot meet the dependency constraint because there is not set of auxiliary functions to value it. This is a welcome result because other accounts of DD-*each* must directly make reference to a requirement that the subject be a plural discourse referent or denote a set (Zimmermann 2002; Kamp and Reyle 1993; etc.). It is nice that we get the requirement for free from a constraint we independently need in order to account for the range of possible D° associates of DD-*each*.

2.3 RESTRICTIONS ON WIDE SCOPE QUANTIFIERS WITH DD-EACH

In the previous section we saw that a functional constraint introduced by DD-*each* can account for the range of D°s that can appear as its associate. I want to take a similar tack in order to account for which D°s DD-*each* can distribute over. Specifically, I will argue for an output constraint that requires every member of the set of auxiliary functions that values the variable associate of DD-*each* to survive into the output.

(27) Auxiliary Function Preservation Constraint

If x_n is a dependent variable associate of DD-*each*, then every function in its set of evaluation functions must survive in the output.

The output constraint in (27) has two independent motivations, which is why it is so attractive. It will explain the fact that the entities picked out by each extension satisfying the nuclear scope should persist in the discourse, which is not true of distributive predication alone. Moreover, it will explain why DD-*each* prefers to be in the scope of distributive predication and universal quantification, as opposed to other quantifiers.

The first piece of evidence for the constraint in (27) is that distributive predication alone does not guarantee the ability of referring back to the collected entities introduced in the nuclear scope with a plural pronoun. The addition of DD-*each* remedies this.

(28) a. ??John and Mary lifted a piano. They were heavy.
b. John and Mary lifted a piano each. They were heavy.
c. ??The students wrote a paper. They were good.
d. The students wrote a paper each. They were good.

We can easily make sense of the pattern in (28) with the Auxiliary Function Preservation Constraint. The auxiliary functions introduced in simple distributive predication do not necessarily survive into the output, but the output constraint introduced by DD-*each* requires this to happen. The result is that when DD-*each* appears we can be sure to be able to gather the entities introduced in the nuclear scope of the tripartite distributive structure into a plural entity, which we can refer back to with a plural pronoun.

There is a similar argument from the behavior of *different* that shows that the output constraint in (27) is on the right track. Notice that distributive predication by itself does not license the availability of *different*, but when we add DD-*each*, it is fine.

(29) a. *The students read a different book.
b. The students read a different book each.
c. *They recited a different poem.
d. They recited a different poem each.

There is an easy account for the differences above if the auxiliary functions that value the associate of DD-*each* must survive into the output. The function of *different* could be to impose an output constraint the requires the values of the extensions on the variable in the nuclear scope to be unique.

(30) $\forall g_n \in G_n$

$g_n(x_j) = a$
$\neq$
$g'_n(x_j) = b$
$\neq$
$g''_n(x_j) = c$
$\neq$
etc.

This sort of constraint over output functions is only possible if they survive into the output. Since we can get *different* in conjunction with DD-*each*, but not with simple distributive predication, this provides evidence that DD-*each* carries with it the constraint in (27) that requires auxiliary functions to survive into the output.

We have just seen clear evidence for the claim that DD-*each* requires auxiliary functions to survive in the output, but there is a more subtle aspect of the constraint in (27) that does important work for us. Notice that it can only be satisfied if every function in the set of auxiliary functions that values the variable associate of DD-*each* survives in the output. Since we throw out extensions on [x_n *each*] that do not satisfy the nuclear scope, the functions defined in the restrictor must each have an extension on [x_n *each*] that satisfies the nuclear scope. This is equivalent to universal quantification over assignments in the set of auxiliary functions, which we have seen before, namely in distributive predication and universal quantification.

(31) a. $[[x_1]_{\phi'} \forall_1 \; [lifted\ the\ piano(x_1)]_{\phi''}]_{\phi}$ where $x_1 = John \oplus Mary$
b. $[[x_1 : man(x_1)]_{\phi'} \forall_1 \; [lifted\ the\ piano(x_1)]_{\phi''}]_{\phi}$

The immediate prediction is that DD-*each* should grammatical in the nuclear scope of a universal. This appears to be the case.

(32) Every student published three papers each.

The interpretation of (32) seems to enforce is the no coauthor reading. This can be brought out more clearly in certain contrastive focus contexts.

(33) Suppose we're arguing about who has the better department. You say every student in your department authored or co-authored 3 papers last year.
a. Well in my department, every student published 3 papers EACH.
b. Well in my department, the students published 3 papers EACH.

Other accounts, which we will consider more closely in §3, will have trouble with these data because they tie the availability of DD-*each* too closely to distributive

predication and the availability of a plural entity to distribute over. The proposal here has no such problem because the Auxiliary Function Preservation Constraint only cares that all of the relevant auxiliary functions survive in the output. The reason we commonly find DD-*each* in the nuclear scope of distributive predication is therefore due to the fact that DD-*each* requires functional dependence and total auxiliary function preservation, which distributive predication ensures through universal quantification over assignments. Crucially, universal quantification does the same, so we correctly predict that DD-*each* should be licit with it as well.

The Auxiliary Function Preservation Constraint can account for the fact that there is no clash with universal quantification, but it also makes the prediction that certain quantifiers will be ungrammatical with DD-*each*, specifically those that do not guarantee that each auxiliary function that satisfies the restrictor will survive in the output. At first pass, this appears to be the case.

(34) a. *Few grad students published 3 papers each.
b. *Most grad students published 3 papers each.
c. *No grad student published 3 papers each.
d. *Many grad students published 3 papers each.

We can attribute the problem to the fact that these quantifiers do not force all auxiliary assignments that satisfy the restrictor to have an extension that satisfies the nuclear scope, so not all such assignments will necessarily survive in the output, contra the output constraint DD-*each* introduces.

(35) Most men lifted the piano.
a. $[[x_1 : man(x_1)]_{\phi'} for\ most\ f_1\ [lifted\ the\ piano(x_1)]_{\phi''}]_{\phi}$

(36) Few men lifted the piano.
a. $[[x_1 : man(x_1)]_{\phi'} for\ few\ f_1\ [lifted\ the\ piano(x_1)]_{\phi''}]_{\phi}$

(37) Many men lifted the piano.
a. $[[x_1 : man(x_1)]_{\phi'} for\ many\ f_1\ [lifted\ the\ piano(x_1)]_{\phi''}]_{\phi}$

It would be strong evidence in favor of the Auxiliary Function Preservation Constraint if we could maintain such a strong categorical distinction between those operators that introduce tripartite structures with universal quantification over assignments versus others that do not. The problem is that the data are more nuanced. It appears that some speakers think some of the illicit quantifiers improve in contrastive focus contexts, even if they do not reach perfect grammaticality.

(38) Suppose we're arguing about who has the better department. You say every student in your department authored or co-authored 3 papers last

year.

a. ?Well in my department, most students published 3 papers EACH.
b. ??Well in my department, many students published 3 papers EACH.
c. ??Well in my department, at least 10 students published 3 papers EACH.

Although I do not have a complete explanation for this effect, I think the Auxiliary Function Preservation Constraint can be maintained. Notice that these quantifiers do not assert that not all of the auxiliary functions that satisfy the restrictor survive in the output. This is a pragmatic effect, which we can cancel.

(39) a. Most students published a paper, in fact all of them did.
b. Many students published a paper, in fact all of them did.
c. ?At least 10 students published a paper, in fact all of the did.

But notice that this is not the case for all quantifiers.

(40) a. *No student published a paper, in fact all of them did.
b. *Few students published a paper, in fact all of them did.
c. *At most 10 students published a paper, in fact all of them did.

Crucially, it is precisely these quantifiers that do not improve with DD-*each* in contrastive contexts.

(41) Suppose we're arguing about who has the better department. You just criticized my department because every student only authored or co-authored 3 papers last year.

a. *Well in your department, no student published 3 papers EACH.
b. *Well in your department, few students published 3 papers EACH.
c. *Well in your department, at most 10 students published 3 papers EACH.

We can make sense of this fact if the problem is that these quantifiers explicitly deny that every function in the set of auxiliary functions survives into the output. This will directly conflict with the Auxiliary Function Preservation Constraint that I have argued accompanies DD-*each*. The reason that a quantifier like *most* could survive with only a mild violation is that it does not require every auxiliary function to survive, but it also does not assert that this is not the case.

It would be very interesting to investigate further how pragmatic strengthening in different contexts affects the availability of DD-*each* in the scope of various quantifiers. Although I do not propose a mechanism for how this would work, I think the problems for the Auxiliary Function Preservation Constraint are not over-

whelming, especially in comparison to its successes. If DD-*each* actually carries the constraint in (27), we can explain why we can easily refer back to the variable associate of DD-*each* with a plural pronoun and why the use the adjective *different* licit, even though we cannot do so with simple distributive predication. Moreover, we can explain why DD-*each* likes to be in the nuclear scope of distributive predication and why it can also easily appear in the scope of a universal. The reason is that DD-*each* places an output constraint on the variable its associate introduces, namely each function in the set of functions that value it must survive in the output. Those quantifiers which require that not all of the functions built on its value condition survive are categorically bad with DD-*each*, even in contrastive contexts, which is what we expect if (27) is correct.

2.3.1 NUMERACY

The Dependency Constraint does good work for us, even though it leaves some open questions. For example, it forces functional dependency, nothing stronger, but some scholars have claimed DD-*each* requires or strongly implies 1:1 covariation Kamp and Reyle (1993). I think that the Dependency Constraint is not enough to to get the truth conditions for DD-*each*, but we need something much weaker. I claim that the set of entities that are values for functions that satisfy the nuclear scope must be non-singleton. The 1:1 intuition that many people have for DD-*each* comes from the fact that it is numerically sensitive. DD-*each* wants every input variable to have a variable of the same cardinality associated with it, and it some situations, the most reasonable interpretation is one where each output variable is evaluated to a unique entity in the model. By thinking about these issues closely, I hope to explain a puzzle about DD-*each* in the scope of a universal, namely DD-*each* does not allow indefinite *a* as an associate in these cases.

Before moving on to my analysis, it is clear that we have to reject the position that DD-*each* requires a 1:1 interpretation. For example, the following sentences is true even if more than one of the children read *War and Peace*.

(42) The children read a book each.

The important things are that not every child read the same book and no two children read a book together. To capture the first fact, I propose that DD-*each* introduces the following constraint.[2].

(43) Nonidentity
It is not the case that for all extensions $g_n \in G_n$ on the variable associate

[2]Notice that it is predicated on the auxiliary functions surviving, which is in line with the Auxiliary Function Preservation Constraint

of DD-*each* x_n, $g_n(x_n) = g'_n(x_n)$.

Nonidentity does not require injectivity, but only says that the value for all extensions on the variable in the nuclear scope must not be the same, which is in accordance with out intuitions.

The reason that some have sensed a strong 1:1 implication is due to the second intuition we identified for (42), namely no two students read a book together. The idea is that each must be associated individually with a variable of the same cardinality, and it is okay if some of the variables, but not all, evaluate to the same entity. There are some cases, though, where it is not plausible that two variables should have an identical value, for example, the sentence in (44).

(44) The students wrote a paper each.

Since it is not plausible for two students to independently write the same paper, unlike reading two different copies of *War and Peace*, we get a strong 1:1 inference in (44).

Although the Dependency Constraint assures each discourse referent in the restrictor is matched with a variable of the same cardinality in the nuclear scope when we have a singular variable, we need an addition to account for cases of plural entities in the nuclear scope.

(45) Cardinal Equality
For all extensions $g_n \in G_n$ on the variable associate of DD-*each* x_n, $|g_n(x_n)| = |g'_n(x_n)|$.

The constraint in (45) not only extends out previous discussion to plural entities, it also explains the fact that DD-*each* is ungrammatical in *at least*-contexts.

(46) Suppose John ate two pizzas and Mary ate three.
  a. John and Mary each at two pizzas.
  b. *John and Mary ate two pizzas each.

(47) Suppose John published one paper and Mary published two.
  a. John and Mary published a paper.
  b. *John and Mary published a paper each.

Example (47) is especially interesting because it shows that indefinite *a* behaves like a numeral when it is the associate of DD-*each*. I want to use this fact to explain why the universal quantifier cannot scope over DD-*each* when its variable associate is indefinite *a*.

(48) a. *Every graduate student published a paper each.

b. Every graduate student published one paper each.

(49) a. *Everyone sang a song each.
b. Everyone sang one song each.

To explain these data, remember that DD-*each* is best with the universal when it is in a contrastive context.[3]

(50) Suppose we're arguing about who has the better department. You say every student in your department authored or co-authored 3 papers last year.
a. Well in my department, every student published 3 papers EACH.

(51) We sang 10 songs last night.
a. No, it must have been more. Everyone sang 2 songs EACH.

In these cases it feels like *each* is given focal prominence and its associate is the numeral. Now we understand the problem in (48-49a). If use of DD-*each* with a universal is tied to focal contexts where the Cardinal Equality Condition is used contrastively, then using a numeral is always the better choice. The reason is that indefinite *a* is numerically equivalent to *one*, but the numerical content of *one* can be focused, while that of the indefinite cannot.

(52) a. *Mary published two papers, but John only published A paper.
b. Mary published two papers, but John only published ONE paper.

(53) a. *John only sang A song, not two
b. John only sang ONE song, not two

The numerical properties of DD-*each* are rich enough to tackle in their own

[3]I have not been clear about why this is. One possibility is that we do not otherwise get much use out of DD-*each* in the scope of a universal. The reason is that *every* is distributive and narrow scope readings of the indefinite are many times already the most salient. Moreover, *every* licensed *different* and plural anaphora.

(i) a. Every student read a different book.
b. Every student wrote a paper. They were pretty good.

One major difference, though, is that we can use *every* in *at least*-contexts, which might indicate why DD-*each* is available in numerically contrastive contexts.

(ii) Suppose John published one paper and Mary published two papers.
a. Everyone published a paper.
b. *Everyone published one paper each.

paper, but in this section I have cleared up a few important issues. We saw that we needed to strengthen the Dependency Constraint because it does not ensure that every extension on the variable in the nuclear scope won't evaluate to the same entity in the model. We fixed this problem with Nonidentity, which we were careful to formulate so as to not require 1:1-ness. We only get the 1:1 inference in certain contexts due to the constraint Cardinal Equality, which requires the value for each extension on the variable associate of DD-*each* to have the same cardinality. Finally, we saw that Cardinal Equality is what is stressed when DD-*each* scopes under a universal, which explains why the indefinite is bad in these cases. The reason is that whatever numerical properties the indefinite has, they are unavailable for focus.

3 PREVIOUS PROPOSALS

The dynamic analysis presented here accounts for various diverse properties of DD-*each* through functional and output constraints, but it is not the only approach. In this section I will consider a few previous treatments in order to see how they stack up to mine. I want to focus particularly on a previous DRT analysis, which can be more easily compared to proposal here. We will see that the major problems are that we cannot simply treat DD-*each* as a distributivity operator, nor can we easily account for the NPs it scopes under by simply thinking of those that participate in distributive predication.

3.1 THE DISTRIBUTIVE OPERATOR ACCOUNT

We might think to treat DD *each* as a distributivity operator that will distribute the subject over the VP in the style of Link (1986).

(54) $[\![\text{each}]\!]=\lambda P\lambda x.\forall x'[x'\Pi x \rightarrow P(x')]$

There are three serious problems with this account. The first is that DD-*each* forms a constituent with the associate that provides its variable.

(55) a. ?Two robots each were built by the scientists.
b. *Two robots were built each by the scientists.

(56) It's two robots each that the scientists are building.

It seems hard to reconcile the fact that DD-*each* forms a constituent with the DO with the requirement in (54) that it combine with the VP. A related problem is that if DD-*each* takes the VP as an argument, then it is not clear how it can place

restrictions on the form of the direct object. We saw, for example, that DD-*each* requires its associate to be functionally dependent, but there is no way to enforce this if DD-*each* composes with the VP.

Finally, we need to distinguish DD-*each* from other instances of *each* that plausibly take the VP as an argument, for example, floating quantifier *each*. Notice that floating quantifier each does not require a DP associate to introduce a variable, nor does it place restrictions on DO DPs

(57) a. The students each danced.
b. *The students danced each.

(58) a. The students each built sandcastles.
b. *The students built sandcastles each.

(59) a. The students each read the book.
b. *The students read the book each.

Example (57) shows that floating quantifier *each* can occur with intransitives, while (58) shows that it is also grammatical with bare plurals. We argued from these cases that DD-*each* needs an associate to introduce a free variable, but since floating quantifier *each* plausibly operates at the VP level, we cannot explain these differences if DD-*each* is also a VP distributivity operator.

3.2 THE LAMBDA ABSTRACTION ACCOUNT

In opposition to distributive operator type accounts, Zimmermann (2002) leaves DD *each* in situ. He claims *each* is inside a PP. The preposition is coindexed with the verb and *each* is coindexed with the DP we distribute over. In the following formula the idea is that Z_i corresponds to the subject, while the relation R_j is coindexed with the verb.

(60) $[\![[_{PP}\ \mathrm{P}^{\circ}\ \mathrm{each}_i]]\!] = \lambda P.\forall z[(z \in Z_i) \rightarrow \exists x[P(x) \wedge R_j(z,x)]]$

When we compute the denotation of the entire sentence, we actually lambda abstract over the coindexed verb and subject. This leads to the first problem because the formula in (60) claims that DD-*each* is equivalent to having an *each* quantifier in subject position with a narrow scope indefinite. This predicts DD *each* should license donkey anaphora, which is wrong.

(61) a. Each professor who read a paper enjoyed it.
b. *The professors who read a paper each enjoyed it.

A second problem with this account is that the formula claims that *each* first combines with property argument. The problem is that we can get quantifiers in object position.

(62) a. The students read at least three books each.
b. The students read exactly three books each.

We also cannot immediately rule out DD *each* in cases where the object denotes a bare plural.

(63) a. *The graduate students ate pizza each.
b. *The students built sandcastles each.

In my account we only need to say that the DPs in (62) introduce a free discourse referent, while those (63) do not. It would be much more difficult to find a natural explanation for why the property-like arguments in (63) are ungrammatical, while explaining why the quantificational elements in (62) actually behave like properties.

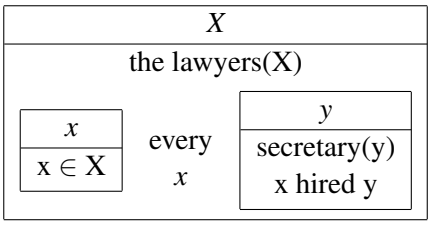
Finally, I feel that Zimmermann's proposal is too heavy handed. Even ignoring the fact that he requires lambda abstraction from object position over the rest of the clause, it stipulates that the subject must denote a plural entity, and forces the denotation of *each* to trigger distributive predication. My proposal only needs to say that DD-*each* needs a free discourse referent associate that must get its value from a set of auxiliary functions, and these auxiliary functions need to survive in the output. This draws together the constraints on associate D°s with the preference of being in the scope of distributive predication. The first is because such variables are free to covary under dependence, while the second is because distribution introduces a set of auxiliary functions bound by a universal. Zimmermann's account does not connect these different aspects of DD-*each*, nor does it easily extend to explain the various output phenomena we encountered, for example, the fact that simple distribution does not license the adjective *different*, while DD-*each* does.

3.3 THE DRT ACCOUNT

Kamp and Reyle (1993) provides an analysis of DD-*each* in the framework of DRT. They take DD-*each* to trigger distributive predication, just like floating quantifier *each* and the distributivity operator.

(64) The lawyers (dist/each) hired a secretary.

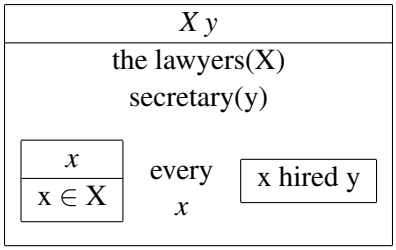
a.



DD-*each* looks leftward for a plural non-quantifying argument phrase X. It forces distribution over this argument by introducing a duplex condition binding a variable $x \in X$. At the same time, it needs an indefinite or cardinal associate that it can make functionally dependent on x.

(65) The lawyers hired a secretary each.

a. *



Since DD-*each* looks leftward for a plural non-quantifying argument, we rule out quantificational subjects because they introduce a singular discourse referent and a duplex condition. This correctly rules out those quantifiers that we saw were bad with DD-*each*, but there is no clear way to explain why the universal is licit in focal contexts. In my analysis, the ungrammatical quantifiers are bad because they prevent all of the auxiliary functions from surviving into the output. Since the universal does not fall into this class, it is not immediately barred from appearing with DD-*each*.

The other major advantage of my proposal is conceptual. Kamp and Reyle (1993) stipulate many of the properties of DD-*each* in the analysis. They do not try to get them to emerge. For example, they independently require for DD-*each* to look leftward for a plural entity and for it to introduce a duplex condition with *every* binding the principal discourse referent. I only have to say that DD-*each* requires is associate to be dependent, which can be fulfilled by any expression that both introduces a set of auxiliary functions and also satisfies the other constraints DD-*each* carries. Distributive predication is just one way for all of the requirements of DD-*each* to be satisfied. Moreover, my analysis finds connections between constraints on the variable associate of DD-*each* and the D° it distributes over. For example, the Dependency Constraint rules out singular subjects because they do not introduce a set of auxiliary functions. The DRT analysis requires the variable associate

of DD-*each* to be free, while ruling out singular subjects with the requirement that DD-*each* look leftward for a plural entity. My proposal does not require this duplication of labor, and at the same time shows interesting theoretical connections between the empirical generalizations.

4 CONCLUSIONS

We have seen that we can understand the distribution of DD-*each* by constraining the input function that values the variable associate of DD-*each* and placing requirements on the output context. Following Farkas (2002), the idea is that DD-*each* makes its variable associate dependent. The reason that DD-*each* commonly occurs in the scope of distributive predication is that its variable can be dependent on the set of functions introduced by the restrictor, moreover, since distributive predication involves universal quantification over assignments, the Auxiliary Function Preservation Constraint is met. We saw that DD-*each* can also occur in the scope of a universal quantifier, but it cannot not occur with other DPs and quantifiers because both of the constraints are not satisfied.

Although the analysis provides a general solution to a cluster of phenomena surrounding DD-*each*, there are still questions. What is missing from this analysis is a explicit account of how contrastive focus operates in DD-*each* constructions. We tied focus to the numerical properties of DD-*each*, and although this seems right, the analysis needs to be completely fleshed out. Similarly, we saw that quantifiers that assert that not all assignments survive in the output are always bad with DD-*each*, but those that are only pragmatically strengthened to achieve this result can be improved in focal contexts. We saw that this made sense, but it would be nice to have a fuller account of how quantifiers, pragmatics, and DD-*each* interact.

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