Articulated Homogeneity in Cumulative Sentences*

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Abstract

In this work, I use cumulative readings of *every* (Champollion, 2010, 2016a; Haslinger and Schmitt, 2018; Kratzer, 2000; Schein, 1993) as a tool to investigate homogeneity in cumulative readings in general. Based on a new observation about the homogeneity properties of cumulative readings of *every*, I argue that the homogeneity properties of cumulative readings arise from the interaction of multiple operators, each operator contributing one exhaustive participation inference which disappears in negative contexts. I identify these operators with the thematic role heads in a Neo-Davidsonian semantics. The resulting theory is able to predict the homogeneity properties of cumulative sentences from the homogeneity properties of their arguments and the position of these arguments.

Introduction

Sentences like (1a), which contain two or more plural arguments, can receive the so-called cumulative reading. This reading can be described as the conjunction of three propositions: 1) some cooks opened some oysters (∃∃), 2) that all the cooks took part in the opening (S_{exh}) and 3) that the oysters all took part (O_{exh}) as well. The reading does not specify which of the cooks opened which of the oysters exactly.

(1) a. The cooks opened the oysters.

b. **Truth-conditions**[1]**:**
every cook opened an oyster (S_{exh})
every oyster was opened by a cook (O_{exh})

The truth-conditions of the negation of (1a), given in (2a), deny the existence of any form of opening involving the cooks and the oysters. In other words, these truth-conditions are not the negation of the truth-conditions of (1b), but only the negation

*All English judgments original to this work were obtained from four native speakers of English. Truth-conditions were elicited using truth-value judgment tasks.

[1] This paraphrase of the truth-conditions is inadequate for actions that can be performed collectively. See section 4.2 for discussion.

of one of the propositions (i.e. ∃∃) which forms the basis of the cumulative reading in the positive sentence (1a).

(2) a. The cooks didn't open the oysters.

b. **Truth-conditions:**
it's not the case that one of the cooks opened one of oysters

c. **Unattested truth-conditions:** $(\neg S_{\text{exh}} \vee \neg O_{\text{exh}})$
either not every cook opened an oyster
or not every oyster was opened by a cook

I will refer to this difference between the truth-conditions of (1a) and its negation (2a) as a *homogeneity effect* (following Löbner (1987)).

In this paper, I will show that properties of this homogeneity effect in cumulative sentences can be illuminated by looking at one related construction: the cumulative readings of *every*. Quite unexpectedly, a singular distributive quantifier like *every* can also give rise to the same cumulative reading (Kratzer, 2000; Schein, 1993), observed in (1a). This is illustrated in (3a). This reading is subject to intriguing restrictions: for instance, it disappears when *every* heads the subject argument.

(3) a. The cooks opened every oyster. ✓(1b)

b. Every cook opened the oysters. *(1b)

The possibility and limited availability of cumulative readings with *every* is a serious puzzle ; it is not straightforward to see how one would account for it under a canonical treatment of *every*.

The main observation is that the cumulative readings obtained in (1a) and (3) are not entirely similar, despite *prima facie* appearances. They differ in what readings they give rise to under negation, as illustrated in (4b). Specifically, (3) seems to deny that all the oysters were opened, i.e. it expresses the negation of O_{exh}.

(4) a. The cooks didn't open every oyster.

b. **Truth-conditions:**
it's not the case that every one of the oysters was opened by a cook $(\neg O_{\text{exh}})$

Thus, the presence of *every* only seems to allow one of the inferences (namely O_{exh}) which, in ordinary sentences, disappears under negation to be negated, but not the other (S_{exh} is not negated).

In light of this data, this paper argues that because they come apart in cumulative sentences with *every*, S_{exh} and O_{exh} must be contributed by two different operators in the syntactic tree. Using the framework of Neo-Davidsonian event semantics, the operators that contribute S_{exh} and O_{exh} are identified with the thematic role heads AGENT and THEME respectively. Concomitantly, this assumption shows that argument separation is not only useful in accounting for cumulative readings *per se* (as argued in e.g. (Kratzer, 2000; Krifka, 1989; Landman, 2000; Schein, 1993)) but is also useful is accounting for their homogeneity properties. Using the trivalent system of Križ (2016), I propose a concrete implementation of the homogeneous thematic role heads. Then, importing Kratzer (2000)'s event-conscious denotation of *every*, the system correctly predicts that cumulative sentences with two definite plurals (hereafter *ordinary cumulative sentences*) and cumulative sentences with *every* differ in the way they do. Specifically, I will show that *every* is able to remove the homogeneity of the THEME head head but not the AGENT head ; cumulative sentences with *every* are thus predicted to give rise to a weakened homogeneity effect, as observed in (4a). Going beyond the case of cumulative reading of *every*, I will show that once the homogeneity removing properties of an item are specified, the articulated system can correctly predict the homogeneity properties of the element in cumulative sentences. This paper will not however try to provide a general theory of homogeneity removal that explains why specific items have the homogeneity removal properties that they do.

The roadmap is as follows: section 1 details the main data points about cumulative readings of *every* given above. Then, in section 2, I develop the articulated theory of homogeneity in cumulative sentences and its compositional rules. Section 3 applies the framework to ordinary cumulative sentences and cumulative readings of *every*. I propose some predictions and extensions of the basic proposal in section 4. I compare the resulting theory to previous approached in section 5 before concluding.

1 Data

This section outlines and details two main facts about cumulative readings of *every*. The first fact is, trivially, that these readings are possible. They receive similar truth-conditions to ordinary cumulative sentences. Second, the negative cumulative reading of *every* differs from the negative cumulative reading of ordinary sentences. I will use these facts to guide the analysis: the commonalities between ordinary cumulative readings and cumulative readings of *every* suggest we give these readings a common source. The homogeneous properties, which are peculiar to *every*, on the other hand, shed light on how this common source interacts with the particular semantics of *every*.

1.1 Fact I: possibility of cumulative readings.

Trivially, our first main fact is that cumulative readings, as in (5), are possible.

(5) The three cooks opened every oyster.

The cumulative readings of *every* constitute a genuine puzzle. In particular, they cannot be reduced to a putative group construal of *every*, where *every*, like a plural definite, denotes the plurality of elements in its restrictor. This possibility is raised because group construals are indeed attested for some speakers of English[2] (represented by %), for some collective predicates.

[2] 3 out of the four speakers consulted accepted the judgments

(6) a.%Every revolutionary met at *Café Musain*.

b.%I stapled every sheet of paper together

These construals are specific to *every* however. Interestingly, Thomas and Sudo (2016) have shown that cumulative readings extend to another singular distributive quantifier, i.e. *each*.

(7) Two farmers sold each sheep to one customer. (Thomas and Sudo, 2016)

However, none of the speakers that accept group construals of *every* accept similar construals for *each* (cf (8)). I conclude that cumulative readings require an independent explanation from group construals.

(8) a. *Each revolutionary met at *Café Musain*.

b. *I stapled each sheet of paper together.

1.2 Fact II: possibility of weak readings.

The second fact has to do with the homogeneity properties of the sentence. As already mentioned in the introduction, cumulative sentences with *every* have a truth-value gap: in a positive environment, the cumulative reading seems to entail that all the investors bought at least one share, as attested by the strange elaboration in (9a).

(9) a. These ten investors bought every one of our shares...

b. ...# nine of them didn't buy any share.

c. **Truth-conditions:**
Every investor bought a share.
Every share was bought by one of the investors.

In negative environments however, the inference disappears. In other words, it is not possible to deny (9a) by pointing out that an investor did not contribute to the buying:

(10) a. I doubt that these ten investors bought every one of our shares...

b. ...# indeed, that investor didn't buy any share.

c. ...✓ indeed, that share was bought by an investor from a different group.

d. **Truth-conditions:**
not [*every share was bought by one of the investors.*]

Let me rephrase in terms that will be useful later on. While (9a) carries both the inference S_{exh} that all the investors did some buying of shares and the inference O_{exh} that all shares were bought by the investors (= $S_{\text{exh}} \wedge O_{\text{exh}}$), its negation seems paraphrasable as the negation of O_{exh} only.

Homogeneity in the presence of definite plurals is not a surprising fact in and of itself. What is surprising is that the truth-value gap differs from the one observed in "*ordinary*" cumulative sentences (with two definite plurals). In normal cumulative sentences, both inferences S_{exh} and O_{exh} disappear under negation. Denying (11) does not amount to denying either exhaustive participation S_{exh} of the subject or exhaustive participation of the object O_{exh}. It amounts to denying that any participation occurred (which I will note $\neg\exists\exists$)

(11) I doubt that these ten investors bought our shares

a. . . . # indeed, that investor didn't buy any share.

b. . . . # indeed, that share was bought my cousin

c. **Truth-conditions:**
not [*one of the shares was bought by one of the investors.*]

So, despite having similar truth-conditions to ordinary cumulative sentences, cumulative sentences with *every* are not entirely parallel to them. This second fact sheds light on the compositional underpinnings of cumulativity: whatever underlies these readings must be able to give rise to both the truth-conditions of (10d) and (11c)

1.3 Summary

We've reviewed the two main facts: the possibility of cumulative readings and the difference in truth-conditions with the normal reading. I repeat below the observed generalizations:

Fact I: *every* gives rise to cumulative readings

Fact II: With *every*, the inference O_{exh} persists under negation

	positive	negative
the cooks . . . every oyster	S_{exh} O_{exh}	$\neg$ O_{exh}
the cooks . . . the oysters	S_{exh} O_{exh}	$\neg\exists\exists$

2 Articulated homogeneity in event semantics

General overview of the account One of the main highlights of the data tour conducted in the previous section is the curious difference between the truth-conditions of ordinary negative cumulative sentences and negative cumulative sentences with *every*. The effects of the minimal replacement of a definite plural by *every* is to maintain O_{exh} under negation, so that the observed reading negates exhaustive participation of the object. In other words, *every* has a *homogeneity-removing effect* (Kriz, 2015). However, this homogeneity-removing effect only affects O_{exh}, i.e. the reading obtained is $\neg O_{\text{exh}}$ not $\neg$ ($O_{\text{exh}} \wedge S_{\text{exh}}$). The fact that the homogeneity-removing effect is localized suggests that the inference itself is localized: there must be some part in the structure which delivers the inference O_{exh}, without delivering the inference S_{exh}, and *every*'s homogeneity-removing effect applies to it. The most straightforward way to implement this suggestion is to have the cumulative truth-conditions $S_{\text{exh}} \wedge O_{\text{exh}}$, which we observe, arise compositionally from the contribution of two separate homogeneity-introducing elements in the structure of transitive clauses. This view represents what I call *articulated homogeneity*.

Which two elements of the structure encode S_{exh} and O_{exh} respectively? These must be elements tightly connected to the position of the subject and the object. I make the assumption that these elements are the thematic role heads AGENT and THEME. Note that this assumption will commit us to a Neo-Davidsonian event semantics[3]. Incidentally, Neo-Davidsonian semantics has often been invoked in accounts of cumulativity (Kratzer, 2007; Landman, 2000; Schein, 1993). Here, we see that the utility of this framework extends to homogeneity. In this system then, S_{exh} and O_{exh} make two independent semantic contributions and each give rise to homogeneity effects. To understand their combined contribution requires some discussion of *homogeneity projection*: how two independent homogeneity effects compose. For concreteness, I adopt Križ (2016)'s treatment of homogeneity and the rules of projection of Strong Kleene logic, which are supported experimentally by Križ and Chemla (2015). Alternatives are possible but these rules deliver the right readings without amendments.

The second piece of the account is to explain how *every* can give rise to cumulative readings and how its semantics interacts with the articulated system for homogeneity laid out here. Here, I will simply borrow Kratzer (2000)'s event denotation for *every* without amendments. This denotation, embedded within the articulated system for homogeneity, correctly predict the truth-value gap of both ordinary cumulative sentences (sentences involving two definite plurals) and cumulative sentences with *every*. I will proceed to discuss how the system may extend to other quantifier than *every* ; the conclusion will be that provided we can independently account for the homogeneity-removing properties of other quantifiers in intransitive sentences, we predict their homogeneity properties in cumulative sentences.

Now that the analysis has been laid out in broad strokes, it is time to elaborate on each component. I will start off by developing a traditional Neo-Davidsonian system (section 2.1). I will then incorporate homogeneity in the thematic role heads, to account for the homogeneous properties of ordinary cumulative sentences (section 2.2). I will end by introducing the projection rules I assume (section 2.3). Having set up the system, I will apply it to the case of ordinary and cumulative readings of *every* in the next section (section 3).

[3] As an anonymous reviewer remarks, the framework commits us *a minima* to some form of separation between the subject and the object. It could be that following Kratzer (2000), that themes are semantic arguments of the verb while agents are separated. In that case, the denotation of verbs would need to encode O_{exh} and the thematic role head AGENT would encode S_{exh}. This is feasible within the framework presented later on. At any rate, the fully separated Neo-Davidsonian semantics presented here allows for a uniform presentation of all homogeneity effects.

2.1 Event semantics

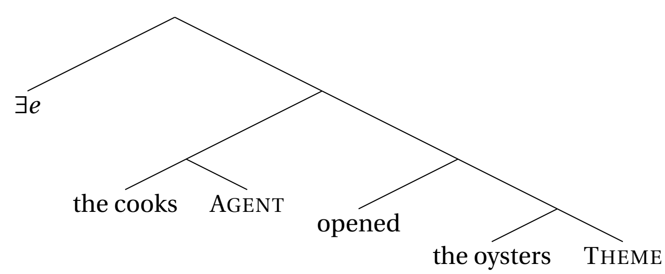
For the reasons outlined in the section above, I assume a Neo-Davidsonian logical form (Kratzer, 2000; Landman, 2000; Parsons, 1990; Schein, 1993). Let me start by briefly detailing the ontological and semantic Neo-Davidsonian assumptions that I will make.

Ontological assumptions I assume that events form a plural domain, whose join operator is written $\oplus$. Each event is connected to some individuals via thematic roles: agent, theme, goal. Following Champollion (2016b); Krifka (1989, 1992), I make two ontological assumptions about thematic roles. First, a thematic role associates only one individual to an event (*thematic role uniqueness*). I will use the abbreviation $\mathsf{agent}(e)$ to mean "*the agent of e*". Second, thematic roles are assumed to be cumulative Krifka (1992): if $\mathsf{agent}(e) = x$ and $\mathsf{agent}(e') = y$, then $\mathsf{agent}(e \oplus e') = x \oplus y$.

Note that this form of ontological cumulativity does not prejudge whether thematic role heads, which belong to the object language, will denote cumulative relations. To emphasize the difference between object language and meta-language, I will always use serif font like agent for the meta-language concept, and use small caps AGENT to write the thematic role heads of the object language.

Semantic assumptions. In line with fully decompositional Neo-Davidsonian assumptions, I assume the verb denotes an event predicate. Its DP arguments combine with the predicate through the thematic role heads AGENT, THEME, GOAL, etc. These thematic role heads are of type $e(vt)vt$, they combine with nominals first and event predicate second. Finally, the event predicate is existentially closed at matrix level. The following LF summarizes these assumptions:

(12)



The critical part of the analysis is to give the proper denotation to thematic role heads. Standardly, one assumes that the denotation of AGENT and other thematic roles incorporates the meta-language relation "*be the agent of*" directly:

(13) Standard denotations (to be modified)

a. $[\![\textsc{Agent}]\!](p) = \lambda x.\lambda e.\ \mathsf{agent}(x) = e \wedge p(e)$

b. $[\![\textsc{Theme}]\!](p) = \lambda x.\lambda e.\ \mathsf{theme}(x) = e \wedge p(e)$

If this is so, the truth conditions of (12) come out as follows:

(14) $[\![(12)]\!]$ is true iff there exists e such that the cooks are the agents of e
the oysters are the theme of e
e is an opening

By the ontological assumptions, and assuming that openings are done individually[4], this must mean that each cook was the agent of some event of opening of an oyster and each oyster was the theme of an opening event by the cooks. In other words, the standard account derives exhaustive participation of the cooks and the oysters (S_{exh} and O_{exh}) right away.

The standard account does not give a handle on homogeneity effects however. It predicts that (15a), the negation of (12) given by the LF in (15b) will simply have the truth-conditions of $\neg(S_{\text{exh}} \wedge O_{\text{exh}})$

(15) a. The cooks didn't open the oysters.

b. not $\exists e$, [the cooks AGENT] opened [the oysters THEME]

For this reason, we cannot adopt the denotations for AGENT and THEME proposed in (13) as is but we need to incorporate homogeneity in the semantics somehow. The next section details an account of homogeneity by Križ (2016), which I will then use to properly define thematic roles.

2.2 Trivalence

The homogeneity effect consists in a truth-value gap between plural sentences like (16a) and their negation (16b): in case half of the ravens croaked, neither (16a) or (16b) may felicitously be used. Križ (2016) proposes to treat homogeneity exactly as such: a gap in the truth-conditions of the sentence. That is to say: in some circumstances, the sentence may fail to yield a truth-value. Thus, the meaning of a sentence must specify three exclusive cases: the truth-conditions, the falsity-conditions and the undefinedness conditions.

(16) a. The ravens croaked.
≈ *all ravens croaked*

b. The ravens didn't croak.
≈ *no raven croaked*

c. **Kriz's denotation**

$$[\![\text{the ravens croaked}]\!] = \begin{cases} \mathsf{true} & \text{if all ravens croaked} \\ \mathsf{false} & \text{if no ravens croaked} \\ \mathsf{undefined} & \text{otherwise} \end{cases}$$

Križ (2016) argues that this truth-value gap is a *sui generis* phenomenon which cannot be assimilated to other "*gappy*" phenomena, like presuppositions or scalar implicatures. The present account, however, does not need to take a stance on the nature of the truth-value gap. In particular, I take Križ (2016)'s account to be a placeholder for any theory of homogeneity. I see trivalence as one way to describe the

[4] I defer discussion of collective action to section 4.2

observed truth-value gap in the sentence. My main interest is where these truth-value gaps are generated -whatever they are, however they may be generated- and how they combine to yield the cumulative readings we observe.

My main contention, motivated by the data on cumulative readings of *every*, is that each thematic role head gives rise to its own gap[5]. In positive sentences, AGENT gives rise to the exhaustive participation inference S_{exh} (e.g. *all of the cooks participated in the event*). In the scope of negation, AGENT should assert total lack of participation. Within Križ's trivalent semantics and the Neo-Davidsonian set-up from the previous section, we can express this contention as in (17). The AGENT head is true of x and p if x is the whole agent of a p-event, and false if no sub-plurality[6] of x participated in a p-event:

(17) $$[\![\textsc{Agent}]\!](p) = \lambda x.\lambda e.\begin{cases} \mathsf{true} & \text{iff } \mathsf{agent}(x) = e \text{ and } p(e) \\ \mathsf{false} & \text{iff for no } y \prec x,\ \mathsf{agent}(y) = e \text{ or } \neg p(e) \end{cases}$$

This denotation of course generalizes to all thematic roles:

(18) $$[\![\textsc{Theme}]\!](p) = \lambda x.\lambda e.\begin{cases} \mathsf{true} & \text{iff } \mathsf{theme}(x) = e \text{ and } p(e) \\ \mathsf{false} & \text{iff for no } y \prec x,\ \mathsf{theme}(y) = e \text{ or } \neg p(e) \end{cases}$$

As far as truth-conditions are concerned, the denotation of these thematic role head is similar to the ones traditionally assumed. The main difference are the falsity conditions: whereas the traditional denotations don't recognize a truth-value gap, these denotations will yield undefinedness whenever some but not all of the cooks participated in the event.

To evaluate the impact of the denotations of AGENT and THEME on the meaning of the whole sentence, we need to understand how the truth-value gap of the sentence will depend on the truth-value gap of its parts: we need a recipe for *homogeneity projection.*

2.3 The Strong Kleene recipe

How do potentially undefined semantic values from sub-constituents determine values of super-constituents? For instance, what are the truth/falsity-conditions of (19a), given the true and false extension of the predicate in (19b)? (These examples are for demonstration only ; I suppress talk of events for the time being.)

(19) a. Some golf player signed the postcards.

b. $$[\![\text{signed the postcards}]\!] = \lambda x.\begin{cases} \mathsf{true} & \text{if } x \text{ signed all the postcards} \\ \mathsf{false} & \text{if } x \text{ signed none of the postcards} \\ \mathsf{undefined} & \text{otherwise} \end{cases}$$

[5] The choice of incorporating homogeneity in the thematic role head rather than the DP itself follows from the fact the definite plurals do not introduce homogeneity in all positions it occurs in (e.g. complement of partitives). I thank an anonymous reviewer for discussion of this point.

[6] I use $\prec$ to mean "*is a sub-plurality*" of. This relation is assumed to be reflexive: $x \prec x$ for all x

It could in principle be stipulated in a lexical item's entry how this item interacts with the undefinedness of the elements it combines with. The denotation in (20) has this feature: it specifies its output to be undefined if its scope is undefined for some values of its restrictor and is not false of any of them.

(20) $[\![\text{some golf-player}]\!] = \lambda p_{et}.\begin{cases} \text{undefined} & \text{if } \forall x,\ x \text{ is a golf player} \rightarrow p(x) = \text{undefined} \\ \text{true} & \text{if } \exists x,\ x \text{ is a golf player} \wedge p(x) = \text{true} \\ \text{false} & \text{otherwise} \end{cases}$

However, we would have a much more explanatory theory[7] if there were a general item-independent recipe for determining, given a denotation written under the assumption that the semantic arguments are bivalent, like (21), how this denotation will combine with potentially undefined arguments. In other words, we would like a principled procedure which converts a standard meaning like (21) into a meaning like (20).

(21) $[\![\text{some golf-player}]\!] = \lambda p_{et}.\exists x, x \text{ is a golf player} \wedge p(x)$

Such a general recipe would mean that we could define lambda-terms in our denotations assuming that the variables they bind are perfectly bivalent and let the recipe handle the other cases. The only cases of undefinedness one would need to specify in the lexical entry of a word would be the cases of undefinedness that arise from the word itself. In this sections to come, once the recipe has been presented, this is precisely what I will allow myself to do: define lexical entries under the assumption that the semantic arguments of a word do not contain undefinedness. In the next section, I highlight one such recipe for trivalence projection, the Strong Kleene projection.

Homogeneity and strong Kleene projection. Križ and Chemla (2015), studying the behaviour of homogeneity in non-monotonic environment, find that the Strong Kleene[8] recipe for projection (extended to first-order logic quantifier) is adequate for homogeneity projection.

The recipe is best explained by considering any instance of undefinedness in an element as an instance of uncertainty about the truth-value of that element. This type of semantics (in the sense of formal logic) for many-valued logic is introduced by Fox (2013); George (2008, 2014); Muskens (1995) in a linguistic context. In its 4-valued instantiation (with undefined truth-values in addition to unknown truth-values), it is known as Belnap-Dunn logics (Belnap, 1977; Dunn, 1976). Following Fox (2013), I will call the 3-valued recipe the Strong Kleene recipe.

[7] Note that epistemologically, the problem of *homogeneity projection* is entirely parallel to the problem of *presupposition projection*. Exactly the same reasons that I used above to motivate having a recipe for homogeneity projection are used to motivate a principled recipe of presupposition projection.

[8] More precisely, they consider the Strong Kleene logic to be a trivalent logic for propositional logic ; they give another name to a first-order extension of this type of trivalent logic. Here, I lump the propositional and first-order logic under the heading "*Strong Kleene*" following Fox (2013), given that they can be described in similar ways.

Under this interpretation, $A \wedge B$, where A is false and B is undefined would correspond to the conjunction of a false statement and a statement whose truth-value is not known. Note that in this case, the truth-value of the whole $A \wedge B$ can be determined without knowing for certain the truth-value of B. It is false, because A is false. As an other example, consider the case $A \vee B$ where A is false and B undefined. No conclusion can be drawn about the truth-value $A \vee B$. It may turn out either true or false, depending on the unknown truth value of B. In our parlance then, this means the truth-value of $A \vee B$ is undefined (it is not known).

This is in essence the recipe. If the truth-value of a constituent may be determined no matter what the undefined values in its parts turn out to be, then that truth-value is the truth-value of that constituent. If, on the other hand, a constituent may be true or false depending on the undefined values in its parts, then that constituent has an undefined truth-value.

We can apply this recipe to classical logical operators, $\vee$, $\wedge$ and $\neg$. For conjunction for instance, the meaning of the whole may only be positively determined if both conjuncts are known to be true, in which case the conjunction is true, or if at least one of them is known to be false, in which case it is false. I leave it to the reader to apply similar reasoning to the other propositional operators. The overall results are given below:

(22) a. $A \wedge B$ is true if both A and B are true
$A \wedge B$ is false if either A or B is false
$A \wedge B$ is undefined otherwise

b. $A \vee B$ is true if either A or B is true
$A \vee B$ is false if both A and B are false
$A \vee B$ is undefined otherwise

c. $\neg A$ is true if A is false
$\neg A$ is false if A is true
$\neg A$ is undefined otherwise

The recipe can similarly be applied to first-order quantifiers. We can positively know that a universal statement "$\forall x, A(x)$" will be true just in case $A(x)$ is true for all x. If some of the $A(x)$ happened to be undefined, i.e. their truth-value were not known, and the rest of them were true, we could not conclude anything regarding the truth of "$\forall x, A(x)$". If finally, at least one of the $A(x)$ is false, then it is certain that "$\forall x, A(x)$" is false, whether or not we know what truth-value A gets for other x. (23) synthesizes the result of applying this reasoning to other first-order quantifiers:

(23) a. $\forall x, A(x)$ is true if for all x, $A(x)$ is true
$\forall x, A(x)$ is false if $A(x)$ is false for some x
$\forall x, A(x)$ is undefined otherwise

b. $\exists x, A(x)$ is true if there exists an x such that $A(x)$ is true
$\exists x, A(x)$ is false if for all x, $A(x)$ is false
$\exists x, A(x)$ is undefined otherwise

This is not evident at first sight but the Strong Kleene recipe is compositional (George, 2008). To determine the truth-value of $[\alpha\ [\beta\ \gamma]]$, we may start off by computing the denotation/truth-value of $[\beta\ \gamma]$, and substitute a certain δ with the same meaning for the complex expression and apply the Strong Kleene reasoning to $[\alpha\ \delta]$. The result will be the same as if we had reasoned about the meaning of $[\alpha\ [\beta\ \gamma]]$ directly.

Alternative presentation. Even if compositional, the Strong Kleene recipe is cumbersome to deal with in actual computations. Here, I present a notational trick which will ease future computations. So far, I have presented the meaning of elements in terms of their truth- and falsity-conditions (e.g. (24a)). Instead, we could write meanings by specifying their truth-conditions and their non-falsity conditions, as in (24b). The two presentations are equivalent ; each can be recovered from the other.

(24) a. $[\![\text{the ravens croaked}]\!] = \begin{cases} \mathsf{true} & \text{iff all ravens croaked} \\ \mathsf{false} & \text{iff no ravens croaked} \\ \mathsf{undefined} & \text{otherwise} \end{cases}$

b. $[\![\text{the ravens croaked}]\!] = \begin{cases} \mathsf{true} & \text{iff all ravens croaked} \\ \mathsf{not\ false} & \text{iff some ravens croaked} \end{cases}$

In the sequel, I will refer to the truth-conditions as the *strong meaning* of an element and to the non-falsity-conditions as its *weak meaning*. Now observe what happens if we rephrase our conclusions about projection out of standard logical operators in terms of the new presentation:

(25) a. $A \wedge B$ is true iff both A and B are true
$A \wedge B$ is not false iff both A and B are not false

b. $A \vee B$ is true iff either A or B is true
$A \vee B$ is not false iff either A or B is not false

c. $\neg A$ is true iff A is not not false (i.e. it is false)
$\neg A$ is not false iff A is not true

d. $\forall x, A(x)$ is true iff for all x, $A(x)$ is true
$\forall x, A(x)$ is not false iff for all x, $A(x)$ is not false

e. $\exists x, A(x)$ is true iff there exists an x such that $A(x)$ is true
$\exists x, A(x)$ is not false iff there exists an x such that $A(x)$ is not false

To the exception of the one downward-entailing operator in (25c), the projection rules all follow one general principle: the strong and weak meanings of the whole are simply the application of the logical operator to the respective strong and weak meanings of its parts. It is *as if*[9] the weak and strong reading formed two independent dimensions of meaning. This makes for an easy statement of complex projection rules. For instance, the truth-conditions of a complex formula in the new presentation would look parallel:

[9] This is not truly a bi-dimensional semantics since the two "*dimensions*" of meaning are not completely independent. The strong meaning, by nature, must always entail the weak meaning.

(26) $\forall x, A(x) \vee B(x)$ is true iff for all x, $A(x)$ is true or $B(x)$ is true
$\forall x, A(x) \vee B(x)$ is not false iff for all x, $A(x)$ is not false or $B(x)$ is not false

By comparison, in the old presentation, the two clauses that specify the meaning would involve completely different logical operators:

(27) $\forall x, A(x) \vee B(x)$ is true iff for all x, $A(x)$ is true or $B(x)$ is true
$\forall x, A(x) \vee B(x)$ is false iff there exists x, $A(x)$ is false and $B(x)$ is false

This generalization about projection holds true of all operators upward-entailing in their arguments. By chance, all of the operators we will consider, with the exception of negation, are of this sort.

For instance, we can reformulate our trivalent denotation for thematic roles in the new presentation as in (28). In its strong meaning, the thematic role head AGENT, for instance, asserts that its argument is the exhaustive agent of the event. In its weak meaning, it simply states that some plural part of its argument is.

(28) a.
$$[\![\textsc{Agent}]\!](p) = \lambda x.\lambda e. \begin{cases} \mathsf{true} & \text{iff } \mathsf{agent}(e) = x \text{ and } p(e) \\ \mathsf{false} & \text{iff for no } y \prec x\text{, } \mathsf{agent}(e) = x \text{ or } \neg p(e) \end{cases}$$
$$= \lambda x.\lambda e. \begin{cases} \mathsf{true} & \text{iff } \mathsf{agent}(e) = x \text{ and } p(e) \\ \neq \mathsf{false} & \text{iff for some } y \prec x\text{, } \mathsf{agent}(e) = y \text{ and } p(e) \end{cases}$$

b.
$$[\![\textsc{Theme}]\!](p) = \lambda x.\lambda e. \begin{cases} \mathsf{true} & \text{iff } \mathsf{theme}(e) = x \text{ and } p(e) \\ \mathsf{false} & \text{iff for no } y \prec x\text{, } \mathsf{theme}(e) = x \text{ or } \neg p(e) \end{cases}$$
$$= \lambda x.\lambda e. \begin{cases} \mathsf{true} & \text{iff } \mathsf{theme}(e) = x \text{ and } p(e) \\ \neq \mathsf{false} & \text{iff for some } y \prec x\text{, } \mathsf{theme}(e) = y \text{ and } p(e) \end{cases}$$

Note that I write $p(e)$ instead of $p(e) = \mathsf{true}$. This is a corollary of the fact that we have a recipe for homogeneity projection. I can assume that p is bivalent (i.e. true or false); the Strong Kleene recipe will handle all cases where p is trivalent and where the notation $p(e)$ may be undefined. Similarly, the "*and*" which appear in the meta-language statement of the predicate can be taken to be a run-of-the-mill bivalent "*and*".

2.4 Summary

This section presented the two critical pieces of the analysis. The first piece is the assumption that exhaustive participation is a trivalent inference, which is encoded in the meaning of thematic role heads. This gives us the source of homogeneity (for cumulative sentences). The second piece is a theory of how homogeneity projects based on Križ and Chemla (2015), the Strong Kleene projection rules.

Now that the compositional rules of the articulated system have been put in place, the next section can now turn to cumulative sentences. I will first show how the assumptions made so far predict the facts about homogeneity in ordinary cumulative sentences. Adapting Kratzer (2000)'s account of cumulative readings of *every*, I will then proceed to show how the articulated system predicts a difference between ordinary cumulative sentences and the cumulative sentences with *every*.

3 Cumulative readings of *every*

3.1 Event denotation for *every*

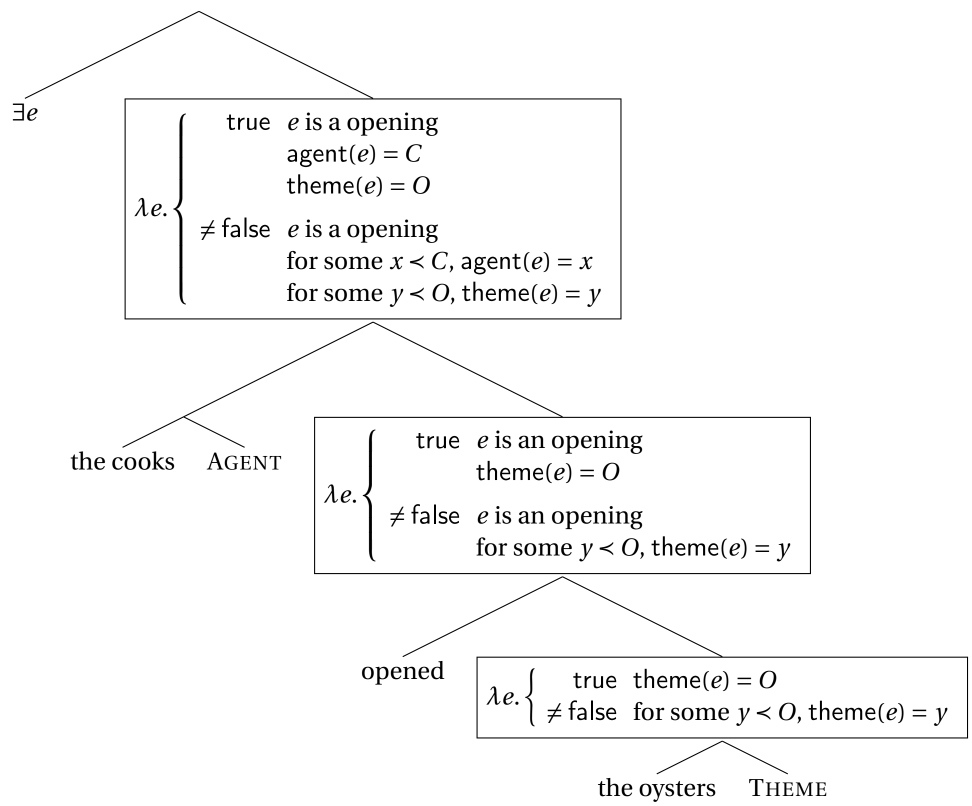
Having presented the assumptions about the sources of homogeneity and how these sources project, I can now compose ordinary cumulative sentences and observe the predictions about their truth and falsity conditions.

3.2 Ordinary cumulative sentences

Let us compose the meaning of the simple sentence in (29a). The computation is made simpler in the new presentation of the Strong Kleene recipe: since the thematic role heads are upward-entailing in their arguments, applying their meaning to the meaning of their argument amounts to applying their strong meaning to the strong meaning of their argument and their weak meaning to the weak meaning of the argument. The composition is given below:

(29) a. The cooks opened the oysters

b.



c. $[\![(29)]\!] = \mathsf{true}$ iff $\exists e$, e is an opening, $\mathsf{agent}(e) = C$, $\mathsf{theme}(e) = O$

d. $[\![(29)]\!] \neq \mathsf{false}$ iff $\exists e$, e is an opening
for some $x \prec C$, $\mathsf{agent}(e) = x$
for some $y \prec O$, $\mathsf{theme}(e) = y$

The strong truth-conditions in (30c) are the same as the truth-conditions obtained by a standard Neo-Davidsonian semantics without homogeneity (as seen in (14) of section 2.1). Just as before, these truth-conditions require exhaustive participation of the subject and the object ($S_{\text{exh}} \wedge O_{\text{exh}}$): all the cooks must have opened an oyster and all oysters must have been opened by a cook.

The weak truth-conditions are new. Recall that the weak truth-conditions represent the set of situations in which the sentence is *not false*. As such, the negation of the weak truth-conditions should amount to the cases where (29a) has a defined truth-value and is false. In other words, these should be the cases where (30a) is true. This is exactly what we observe: the negation of the weak truth-conditions assert that there is no event of opening involving some of the cooks as agents and some of the oysters as themes. To put it simply, no cook opened any oyster. These are indeed the intuitive truth-conditions of (30a).

(30) a. The cooks didn't open the oysters

b. **Intuitive truth-conditions:**
not [some of the cooks opened some of the oysters]

The articulated system for homogeneity in cumulative sentences correctly captures the homogeneity gap displayed by ordinary cumulative sentences. But it also captures the homogeneity gap of cumulative readings of *every*. To show this, the next section imports, without amendments, Kratzer (2000)'s account for cumulative readings of *every* in the current system. Combined with the articulated system, the correct truth-value gaps for the cumulative sentences with *every* are predicted.

3.3 Cumulative readings of *every*

To capture cumulative readings, Kratzer (2000) (see also Champollion (2016b); Ferreira (2005); Ivlieva (2013); Zweig (2008)) assumes that the denotation of *every* makes reference to events. This step represents a strong departure from standard Montagovian assumptions but it is empirically motivated. An argument for making this step comes from Schein (1993) (originally from Taylor (1985)). He observes that when modifiers to the event predicate (underlined in (31)) appear with *every*, they modify an ensemble event composed of elements from the scope of *every*. In (31a) for instance, *unharmoniously* describes an event containing one note-striking for each student. In (31b), the time adverbial can quantify the time that the event of eating all the cookies lasted.

(31) a. <u>Unharmoniously</u>, every student struck a note on the piano. (Schein, 1993)

b. She ate every cookie <u>in less than two minutes</u>.

c. Every ship departed, <u>one in the wake of the other</u>.

The simplest way to contend with these observations is to wire *every* to deliver the ensemble event that these adjuncts modify. This in particular implies that the semantics for *every* makes reference to events. The denotation proposed in Kratzer (2000), which I present below with cosmetic adjustments, is specifically designed to deliver the ensemble events revealed by the previous examples. To simplify the presentation, I adopt some notation: if p and p' are two predicates of events, let us call $p + p'$, the set of events[10] that are the sum of a p event and a p' event.

(32) a. $p + p' = \{e \oplus e' \mid e \in p, e' \in p'\}$

b.
$$\begin{array}{c} \{e_1, e_2, e_3\} \\ + \\ \{e'_1, e'_2\} \\ = \\ \{e_1 \oplus e'_1, e_2 \oplus e'_1, e_3 \oplus e'_1, e_1 \oplus e'_2, e_2 \oplus e'_2, e_3 \oplus e'_2,\} \end{array}$$

This notation can be generalized to sums of arbitrarily many predicates and I use the symbol Σ to represent such a sum. With this notation in place, the effect of *every* is simply to add together the event predicates that corresponds to each element in the restrictor of *every*. As the example in (33b) shows, this denotation for *every* creates an ensemble event, just as desired.

(33) a. $[\![\text{every NP}]\!] = \lambda p_{evt}.\ \sum_{x \in [\![\text{NP}]\!]} p(x)$

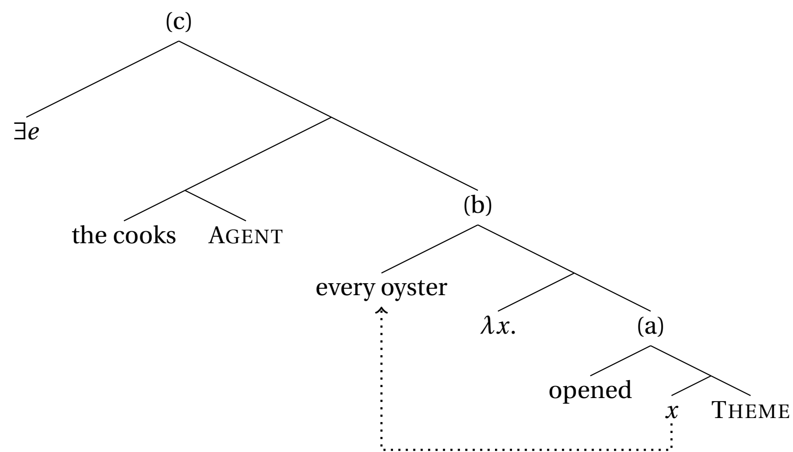
b.
$$\begin{aligned} [\![\text{every ship departed}]\!] &= [\![\text{ship 1 departed}]\!] + [\![\text{ship 2 departed}]\!] + \ldots \\ &= \lambda e.\ e = e_1 \oplus e_2 \oplus \ldots \end{aligned}$$

where e_1 is a departure of ship 1,
e_2 is a departure of ship 2, etc.

Having assumed this denotation, let us compose a cumulative sentence with *every* and check that it differs from ordinary cumulative sentences in exactly the way that we observed in section 1.2. Since *every* is a scope-taker, there will be several LFs to consider. Let me focus on the LF that delivers the correct reading, given in (34). We will return to alternative LFs in section 4.1.

[10] Here, I identify predicates of events and sets of events.

(34)



There are three relevant stages of composition that are worth discussing. At stage (a), the variable x is incorporated in the main verb's event predicate by the homogeneous THEME head. (35a) gives the result that is delivered by applying the denotation of THEME blindly.

(35) a. $[\![(\text{a})]\!] = \lambda e. \begin{cases} \textsf{true} & e \text{ is a writing and } \textsf{theme}(e) = x \\ \neq \textsf{false} & e \text{ is a writing and for some } x' \prec x,\ \textsf{theme}(e) = x' \end{cases}$

b. $[\![(\text{a})]\!] = \lambda e.\ e \text{ is a writing and } \textsf{theme}(e) = x$

Observe that since x is a singularity[11], there is no difference between x being the theme of the event and some part of x being the theme of the event. In other words, the strong and the weak truth-conditions are the same and we can rewrite (36a) as (36b). This means that *every*, by virtue of quantifying over singularities, negates the effect of homogeneity in the thematic role head THEME. However, it will have no effect on the homogeneity effect introduced by AGENT.

At stage (b), *every* forms the ensemble event which combines an opening of each oyster (cf (36a)). By the ontological assumptions, this is just an event of opening the oysters (cf (36b)). As you can note, the meaning we obtain at this stage corresponds to the strong meaning obtained for the corresponding VP in (29b) ; there is no longer any trace of homogeneity from the object position.

(36) a. $[\![(\text{b})]\!] = \sum_{x \text{ is an oyster}} \lambda e.\ e \text{ is an opening and } \textsf{theme}(e) = x$

b. $[\![(\text{b})]\!] = \lambda e.\ e \text{ is an opening and } \textsf{theme}(e) = O$
where O is the plurality of oysters

Finally, we incorporate the cooks in event predicate through AGENT and existentially close the event predicate.

[11] To be more faithful to how the composition actually unfolds, the predicate abstracted over by $\lambda x.$ is formed for both singular and plural arguments but will only be evaluated on singular arguments. So we need only worry about the case where x is a singular.

(37) a. $[\![(37)]\!] = \mathsf{true}$ iff $\exists e$, e is an opening
$\mathsf{theme}(e) = O$
$\mathsf{agent}(e) = C$
where C is the plurality of cooks

b. $[\![(37)]\!] \neq \mathsf{false}$ iff $\exists e$, e is an opening
$\mathsf{theme}(e) = O$
for some $y \prec C$, $\mathsf{agent}(e) = y$

Are these truth/falsity-conditions adequate? The strong truth-conditions do not differ from (29b). This is as desired: normal cumulative sentences and cumulative sentences with *every* do not differ in positive contexts.

The difference lies in the weak truth-conditions. The weak truth-conditions in (37b) assert that there was an opening event with all the oysters as theme and part of the cooks as agents. In other words, the inference O_{exh} that every oyster was opened by some of the cooks. The negation of that $\neg O_{\text{exh}}$ - i.e. not every oyster was opened by a cook (or at all) - should correspond to the truth-conditions of (38a). As discussed in section 1.2, this is the desired result:

(38) a. The cooks didn't open every oyster.

b. **Intuitive truth-conditions:**
not [every oyster was opened by some of the cooks] $(=\neg O_{\text{exh}})$

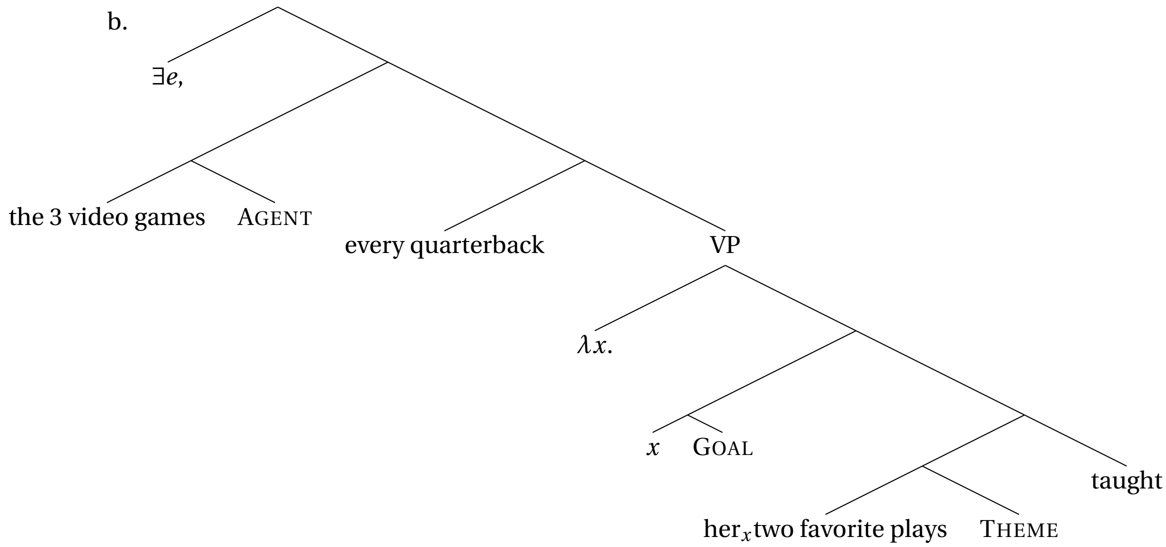
This computation shows that *every*'s event denotation from Kratzer (2000), along with the articulated system for homogeneity, achieves our two desiderata: we now have an account of how cumulative readings of *every* are possible and how the difference between cumulative readings of *every* and ordinary cumulative readings comes about.

As a further illustration of the system and as a sanity check, let us try to account for a modified version of Schein (1993)'s famous video-games example[12].

[12] Schein uses an indefinite, where I use a plural definite containing a bound pronoun. Both examples illustrate the same conceptual point, namely that *every* retains its distributive semantics even when read cumulatively (Champollion, 2010). I chose the latter because 1) it evacuates a question of how to integrate the indefinite's quantification within event semantics (Champollion, 2014), 2) indefinites show some unaccounted for homogeneity-removing effect (Kriz, 2015) (see discussion in section 3.4). Discussing either point would lead us astray from this section's main argument.

(39) a. The video-games taught every quarterback$_7$ her$_7$ two favorite plays

b.



c. $[\![\text{VP}]\!] = \lambda x.\lambda e. \begin{cases} \text{true} & \text{iff teach}(e) \wedge \text{theme}(e) = x\text{'s two favourite plays} \\ \neq \text{false} & \text{iff teach}(e) \wedge \text{theme}(e) \subset x\text{'s two favourite plays} \end{cases}$

d. $[\![\text{every quarterback } \lambda x.\ \text{VP}]\!]$
$= \lambda e. \bigoplus_{x \in \text{quarterback}} \lambda e. \begin{cases} \text{true} & \text{iff teach}(e) \wedge \textsc{Goal}(e) = x \wedge \text{theme}(e) = x\text{'s two favourite plays} \\ \neq \text{false} & \text{iff teach}(e) \wedge \textsc{Goal}(e) = x \wedge \text{theme}(e) \subset x\text{'s two favourite plays} \end{cases}$

e. $[\![(39\text{b})]\!]$ = true
iff $\exists e$, $\textsc{Agent}(e) = \iota\text{video-games} \wedge e = \bigoplus_{x \in \text{quarterback}} \lambda e'.\text{teach}(e') \wedge \textsc{Goal}(e') = x \wedge \text{theme}(e') = x\text{'s two favourite plays}$
$[\![(39\text{b})]\!] \neq$ false
iff $\exists e$, $\textsc{Agent}(e) \subset \iota\text{video-games} \wedge e = \bigoplus_{x \in \text{quarterback}} \lambda e'.\text{teach}(e') \wedge \textsc{Goal}(e') = x \wedge \text{theme}(e') \subset x\text{'s two favourite plays}$

The strong truth-conditions state that there are 3 video-games which were the teachers in a series of events where each quarterback learned her two favorite plays. Because *every*'s denotation is borrowed from her work, the predictions for the strong truth-conditions match the ones made in Kratzer's theory. In other words, the account of Schein (1993)'s sentence requires nothing more than Kratzer's original denotation.

The framework here however makes an extra prediction, compared to previous literature on this sentence. It predicts, in addition to the circumstances in which the sentence is true, the circumstances in which the sentence is false. To see this, let us turn our attention to the weak truth-conditions: they state that some of the video-games were the teachers in a series of events where each quarterback learned at least some of her favorite plays. For this to be false, it has to be that at least one player was not taught any of her favorite plays by any of the video-games. These are the conditions under which the negation of Schein's sentence in (40b) is predicted to be true. As far as my consulting goes, this prediction is correct:

(40) The video-games didn't teach every quarterback her two favourite plays.

3.4 Negation and homogeneity removal

In the previous section, we have seen that by virtue of quantifying over singularities, *every* effectively cancels the truth-value gap associated with the THEME role head in cumulative sentences. This effect does not extend to AGENT so the sentence still bears a gap, albeit a narrower gap than that exhibited by a cumulative sentence with two definite plurals.

However, quantification over singularities is not the final word on homogeneity removal beyond *every* and even for *every* itself[13]. Indeed, other quantificational DPs (Kriz, 2015)[14] have been argued to remove homogeneity, for which this strategy is not applicable. Cases in point include *all* (as seen in the previous section), and plural indefinites, including numerals.

(41) a. All the pins fell.
b. It's not the case that all the pins fell.
↔ negation of (41a)

(42) a. More than two pins fell.
b. It is not the case that more than two pins fell.
↔ negation of (42a)

Because these plural quantifiers can combine with collective predicates, it is unreasonable to assume that they too always or only quantify over singularities. As a result, their homogeneity-removing properties must be accounted for differently. Even *every*, in the dialects and contexts where a collective use is possible (cf section 1.1), seems to act as a homogeneity remover, as a reviewer notes.

(43) a. Every revolutionary met at Café Musain.
b. Not every revolutionary met at Café Musain.
↔ negation of (43a)

If all quantifiers similarly trigger homogeneity removal (Križ, 2016), then the account of the homogeneity removal properties of *every* in terms of quantification over singularities seems to miss a generalization[15]. Hence, there is more to homogeneity

[13] I thank two anonymous reviewers for bringing up this point.

[14] See also Gajewski (2005) on generic plurals for similar observations.

[15] Beyond plurals, there does seem to be a correlation between overt quantification and homogeneity, as discussed by Corblin (2008). Bare conditionals are homogeneous (Bassi and Bar-Lev, 2018; Higginbotham, 1986; Leslie, 2009), but overtly quantified conditionals aren't. Object of incremental theme verbs (Glass, 2018; Krifka, 1989) (e.g. *I didn't drink the bottle of milk* ⇝ *I drank none of it*) are homogeneous but lose their homogeneity when an overt quantification over parts is added (i.e. *I didn't drink the whole milk*)

and homogeneity-removing than the theory of homogeneity presented in this paper predicts. This is to be expected since we haven't made many stipulations about the nature of homogeneity, beyond its mode of projection, treating it as a simple undefinedness. The underspecified framework presented here may not indeed be able to explain the properties of *all* and plural indefinites ; this task, left to future research, will involve a more concrete implementation of homogeneity than was offered here.

Yet, the articulated account is still explanatory. Specifically, *taking the homogeneity-removing properties of* all *and plural indefinites for granted,* (as they are observed in the simple intransitive sentences shown above), the account predicts that they would show the same homogeneity properties that *every* does in cumulative sentences. Namely, the inference expressed by S_{exh} should not be part of what is negated in a negative cumulative sentence but the inference O_{exh} should. This is what we find indeed[16] in (44) and (45): the positive sentence asserts that all three ATMs distributed at least one password and more than 40 passwords were distributed overall ; the negative sentence, on the other hand, asserts that less than 41 passwords were distributed, irrespective of how many ATMs performed the distribution.

(44) a. The three ATMs distributed more than 40 passwords.

b. *the number of passwords distributed by an ATM is more than 40* (O_{exh})
every one of the 3 ATMs distributed some passwords (S_{exh})

(45) a. I doubt that the three ATMs distributed more than 40 passwords.

b. **Attested reading:** *the number of passwords distributed by an ATM is less than 41* ($\neg O_{\text{exh}}$)

c. **Unattested reading:** one of the following is true

- *the number of passwords distributed by an ATM is less than 41* ($\neg O_{\text{exh}}$)
- *not every one of the 3 ATMs distributed some passwords* ($\neg S_{\text{exh}}$)

In the context of the current account, "*taking homogeneity-removing effects for granted*" effectively means that I stipulate that the homogeneity removers must co-occur with an assertion operator A which converts undefined truth-values to false, effectively closing the truth-value gap. This operator is defined in (46). A more complete account of homogeneity may be able to derive the effect of this operator from first principles.

(46) $$[\![\mathrm{A}]\!](\theta_{evt}) = \lambda x.\lambda e.\begin{cases} \text{true} & \text{if } \theta(x)(e) \text{ is true} \\ \text{false} & \text{otherwise} \end{cases}$$

With this operator, the computation runs as follows:

[16] In order to provide a semi-formal implementation below, I don't discuss the case of downward-entailing quantifiers like *less than 4*, which are independently challenging in event semantics (Landman, 2000).

(47) $\exists e$, [AGENT the three ATMs] distributed [more than 4 passwords [A THEME]]

$$[\![\text{more than 4 passwords [A THEME]}]\!] = \lambda e. \begin{cases} \text{true} & \exists X \in \text{passwords}, |X| > 4 \wedge \text{theme}(e) = X \\ \text{false} & \text{otherwise} \end{cases}$$

$$[\![\exists e, \text{[AGENT the three ATMs] distributed more than 4 passwords [A THEME]}]\!]$$
$$= \begin{cases} \text{true} & \exists e, \text{agent}(e) = \iota\text{ATM} \wedge \exists X \in \text{passwords}, |X| > 4 \wedge \text{theme}(e) = X \\ \neq \text{false} & \exists e, \text{agent}(e) \prec \iota\text{ATM} \wedge \exists X \in \text{passwords}, |X| > 4 \wedge \text{theme}(e) = X \end{cases}$$

The strong truth-conditions are cumulative: the sentence is true if each of the three ATMs distributed at least one password and overall, more than 4 passwords were distributed by the ATMs. The weak truth-conditions state that more than 4 passwords were distributed by the ATMs but does not impose that all the ATMs contributed to the distribution. The weak truth-conditions correctly match the negation of the truth-conditions elicited in (45) for the negative sentence[17].

To sum up, the articulated system for homogeneity predicts the homogeneity-removing effect of *every* as a by-product of its quantifying over singularities. However, the homogeneity-removing effect extends to most other quantifiers in a way that puts in question whether quantification over singularities is truly the explanation for *every*'s homogeneity removing effect. Yet, taking the homogeneity-removing effect of these items as an axiom (through a stipulated *A* operator), the system is able to predict the homogeneity behavior of these items in cumulative sentences.

3.5 Summary

In this section, I have applied the system of articulated homogeneity for cumulative sentences to ordinary cumulative sentences and cumulative sentences with *every*. The only addition to the system of the previous section was the introduction of an event-conscious denotation for *every* from Kratzer (2000), which I borrowed wholesale. As we saw, this simple system was sufficient to account for the difference between ordinary cumulative sentences and cumulative sentences with *every*. The current approach does not predict the homogeneity-removing properties of plural quantifiers. Despite not being able to predict their homogeneity properties, the articulated system still provides a handle on how the homogeneity-removing effect of these quantifiers will manifest itself in cumulative sentences. The articulated system in place, the next section explores finer-grained predictions of the account: cumulative asymmetries, collective predication and subject-inexhaustive readings.

4 Extensions

This section explores ways in which the articulated view can be extended or refined. We will study three other aspects of cumulativity. First, I will discuss the asymmetries exhibited by cumulative readings of *every*. Following Champollion (2010);

[17] One reviewer worry that removing homogeneity of the thematic role wholesale might be too blunt because of sentences like *the cooks didn't open every oyster and the mussels.* Here, "*the mussels*" is read homogeneously (i.e. no mussels) but not "*every oyster*". To avoid this problem, the *A* operator could be assumed to be part of the semantics of the quantifier, rather than attaching to the thematic role itself. For simplicity, I do not pursue this alternative.

Haslinger and Schmitt (2018); Zweig (2008) but *pace* Kratzer (2000), I will provide evidence that cumulative readings of *every* are only available when the definite plural c-commands *every* in its base position. I will show that this fact is in fact predicted by Kratzer (2000)'s own account, given the rigid position of thematic roles in the syntactic structure. Second, I will discuss the case of collective action in cumulative sentences, building on observations by Manuel Križ, and provide a small modification to the current account. Third I will explore and test a prediction of the account: if S_{exh} and O_{exh} make independent homogeneous contributions, one may expect to find cases where the homogeneity of S_{exh} is removed and the homogeneity of O_{exh} is maintained, i.e. the exact opposite of what we find in cumulative sentences with *every*. Using data from French, I show that this prediction seems validated.

4.1 C-command asymmetries

Data. An important fact about cumulative readings of *every* has been neglected. The cumulative readings, which are natural when *every* occupies the object position, are absent when it is in a subject position: (48b) seems to imply that the same oyster can be opened multiple times.

(48) a. The cooks opened every oyster. (✓cumulative)

b. Every cook opened the oysters. (*cumulative)

The correct description of the asymmetry is controversial. On the one hand, Kratzer (2000), who noticed the asymmetry, used this fact[18] to argue for a distinguished status of the thematic role THEME. We could state her generalization as follows: a cumulative reading is only available when the co-argument of *every* does not bear the thematic role THEME. However, as pointed out in Champollion (2010); Zweig (2008), the asymmetry does not simply seem to be a AGENT/THEME asymmetry. They point out that the passive version only has the distributive reading which in our case, would mean that oysters can reseal themselves after opening. If all it takes for a cumulative reading to appear was for *every* to be a THEME, the sentence in (49) would be predicted felicitous under the cumulative reading:

(49) Every oyster was opened by the cooks

Champollion's own generalization is one of c-command[19]: *every* needs to be c-commanded by the plural it enters a cumulative relationship with.

Champollion's criticism of Kratzer's claim is suggestive but one could maintain that Kratzer's claim that only AGENT can give rise to the cumulative reading[20] is basically correct but passives, for unknown reasons, disrupt the cumulative construals.

[18] She draws other arguments for her proposal. Thus, dismissing her claim about cumulative reading of *every* does not immediately threaten the original proposal.

[19] Champollion does not specify at what level the c-command must hold (LF, Spell-out or otherwise). Below, I will try to ascertain what the facts are by looking at moved constituents.

[20] D. Fox (p.c.) suggests that this criticism does not extend to an alternative formulation of Kratzer's generalization: The cumulative reading is only available when *every* is c-commanded by a DP bearing a "*separable*" thematic role, i.e. incorporated in the verb via a thematic role head and not by direct functional

To render Champollion's generalizations truly impermeable to this objection, let us look at a wider range of environments. In particular, I propose to turn to double-object constructions which have well-defined rigid scope relations[21]. I construct an example for each position that the plural and *every* could appear in[22]. The third argument slot is filled with a singular. There are six such combinations:

(50) Agent/Theme

a. The twelve challenges taught Hercules every cardinal virtue. (cumulative)

b. Every challenge taught Hercules the four cardinal virtues. (#cumulative)

(51) Agent/Goal

a. The ten servers sent every customer an e-mail. (cumulative)

b. Every server sent the ten customers an e-mail. (#cumulative)

(52) Goal/Theme

a. Anya gave the ten charities in Boxborough every penny she had earned. (cumulative)

b. Anya gave every charity in Boxborough the fifteen checks she had earned. (#cumulative)

I summarize the results of these investigations in the following table:

		DP "*every*"		
		Agent	Goal	Theme
Plural DP	Agent		✓	✓
	Goal	#		✓
	Theme	#	#	

This table does not reveal a distinguished status of the theme: the cumulative reading is unavailable even when the co-argument of every is not a Theme, but a Goal. Champollion's generalization about the availability of cumulative readings seems vindicated[23]: whenever the thematic role head associated with a plural expression

application. I don't know which of these two formulations Kratzer (2000) meant. However, note that if the latter interpretation is correct, then her generalization is only distinguished from Champollion (2010)'s generalization in cases where *every* is c-commanded by a plural argument bearing a non-separable thematic role. But arguments bearing non-separable thematic roles also happens to be the lowest, because they are semantic arguments of the verb and must combine with it first to form an event predicate. If both generalizations make the same prediction in the cases that are testable, we should provisionally opt for the simpler one, Champollion's, which only makes reference to c-command.

[21] For a discussion of asymmetries in ditransitives with the Italian quantifier *ogni*, see Flor (2017)

[22] A definite read non-maximally in the scope of *every* may yield a reading that is similar to the cumulative reading. To avoid this confound, I used definites with numerals. These definites typically do not tolerate exceptions.

[23] A reviewer notes that both judgments reported in (52) hold of the dative construction (e.g. *Anya gave every penny she had to the charities in Boxborough*). They observe that this is unexpected given classical arguments from binding and NPI licensing (Larson, 1988) that in the dative construction, the theme c-commands the goal rather than vice-versa. This is indeed a puzzle. One reaction to this discrepancy is

is higher than the argument position of the DP headed by *every* in the c-command hierarchy of (53), a cumulative reading is available.

(53) **Hierarchy of cumulative readings:** AGENT ≫ GOAL ≫ THEME

Because of these data points, I take Champollion's generalization to be basically correct. However, we can go beyond it. One reviewer, for instance, asks whether what matters is the position of the thematic role heads or the position of the arguments themselves. On all the examples considered so far, the difference is immaterial, because plural arguments and thematic role heads, as per our assumed syntax, are sisters at LF. Thus, our data so far allow us to state the hierarchical generalization either way.

However, considering data involving moved arguments, I believe that the generalization stated in terms of thematic role heads is preferable over an alternative which only mentions the arguments' position. In Chatain (2020), I provide three arguments from three different types of movement. For sake of brevity, I will only discuss the case of *wh*-movement in English.

wh-movement is known to create new cumulative readings with ordinary arguments, as the following examples from Sauerland (2001) show:

(54) a. These five reviewers believed that a student of theirs had written those eight abstracts.
(# cumulative)

b. Which eight abstracts did those five reviewers believe that a student of theirs had written?
(✓ cumulative)

However, *wh*-movement does not give rise to a cumulative reading for a plural object in a sentence with *every* as the subject, as the contrast between (55a) and (55b) shows.

(55) a. Which 25 paintings did every appraiser examine?
⇝ *every appraiser examined 25 paintings*[24]

b. Which 25 paintings did the appraisers examine?
⇝̸ *every appraiser examined 25 paintings*[25]

that the cumulative asymmetries are sensitive to a different hierarchy than the hierarchy of c-command between the DPs, which we could name the hierarchy of thematic roles. This is in line with observations that we will discuss later that the asymmetries are dependent on the position of the thematic role heads, rather than the actual position of the DPs themselves. Another reaction is that the data on cumulative asymmetries warrant calling into question the standard c-command structure suggested by the binding and NPI diagnostics (see Barker (2012) for a criticism of binding diagnostics). This line is independently defended in Janke and Neeleman (2012); Lechner (2003); Phillips (1996, 2003), on the basis of wholly different data, the so-called Pesetsky paradoxes (Pesetsky, 1996).

[24] The question is ambiguous between a pair-list reading where appraisers could have examined different paintings and a unique answer where they all examined the same paintings. The inference holds under both readings.

[25] This question is also ambiguous. Under at least one reading, namely the cumulative reading, the inference does not hold.

Thus, while the object "*which 25 paintings*" does c-command "*every appraiser*" in (55a), the cumulative reading is not available. This is as is expected if what matters to the presence of a cumulative reading is whether the thematic role head THEME c-commands of *every*. Assuming the position of THEME is not altered by *wh*-movement, the THEME still falls within the scope of *every* failing to yield the desired cumulative reading.

In conclusion, the generalization that arises from the data is that *a cumulative reading with* every *is only available when it is c-commanded by the thematic role head of the plural argument it tries to enter a cumulative reading with.*

Analysis. I contend that Kratzer (2000)'s analysis alone is sufficient to predict this generalization. To start off the demonstration, let us consider an alternative LF for the cumulative sentence with *every*, repeated in (56a), where *every* receives a wider scope than the subject.

(56) a. The cookes opened every oyster.

b. $\exists e$ every oyster λx. [the cooks AGENT] opened [x THEME]

This LF has a meaning: it requires that for every oyster, there is an event where all the cooks open that oyster. This reading is a (doubly-)distributive reading, not a cumulative reading. It is implausible in (56a), because oysters cannot be opened multiple times, but is definitely available with the appropriate lexicalization:

(57) The fans in this audience have read every one of your books.

This would seem to show that every time *every* out-scopes its plural co-argument, it will only generate a distributive reading. This situation is precisely that which obtains when *every* lies in subject position. In particular, the LF in (58b) is bound to deliver a distributive reading. In other words, we expect an asymmetry between subject and object *every* in the availability of the cumulative reading that we observe.

(58) a. Every cook opened the oysters.

b. $\exists e$ every cook λx. [x AGENT] opened [the oysters THEME]

If the scope of *every* is the issue, is it possible that the cumulative reading may be obtained by scoping "*the oysters*" above *every* as in (59)? Remember that the possibility of movement does not seem to create new cumulative readings, as seen in (55).

(59) $\exists e$ the oysters λy. every cook λx. [x AGENT] opened [y THEME]

However, this scope assignment is idle because scoping a type *e* element is vacuous. One may hope to make this scope assignment meaningful, either replacing *the oysters* by a quantifier like *three oysters*[26] or adding a covert operator, e.g. DIST, between the DP and the λ-abstract:

[26] I thank one of the reviewers for bringing up this case

(60) $\exists e$ the oysters $\textsc{Op}_?$ λy. every cook λx. [x AGENT] opened [y THEME]

Neither strategy will achieve the missing cumulative reading. To see this, observe that the predicate "λy. [every cook AGENT] opened [y THEME]", constructed by scoping, is non-empty if and only if there is some y which all cooks opened. This is typically not the case in the cumulative scenarios we have been considering, where every cook opened a different set of oysters. Thus, in worlds where the typical cumulative scenario is true, this predicate would be empty. It is hard to see what independently needed semantic operator could turn an empty predicate into a non-empty one[27], as is required for the sentence to be true. Similarly, use of a quantifier like "*three oysters*" instead of a definite plural, in combination with the empty predicate, would only contribute to make the sentence false in cumulative scenarios[28].

The generalization predicted by Kratzer's denotation is that *a cumulative reading with* every *is only available when it is c-commanded by the thematic role head of the plural argument it tries to enter a cumulative reading with.* This matches what we observed in the data section.

4.2 Collective action

Another fact carefully neglected by the analysis above is the case of collective predication. I have regularly used the predicate *opened the oysters*, which is usually a one-person-task and can only be done once to oysters. I now turn to predicates which allow collective participation. I will compare the predictions of the current system to empirical generalizations drawn in Kriz (2015); Križ (2016) about homogeneity in collective predicates and amend our denotations to fit the generalizations from these works.

Turning to predicates which allow collective participation, the strong truth-conditions derived by the system seem correct (cf (61b)). Indeed, it does not matter how many movers were involved in the carrying of each individual piano ; so long as the carriers of all the pianos add up to the totality of movers, our ontological assumptions will guarantee the existence of the event in (61b).

(61) a. The movers carried the pianos upstairs.

b. **Truth-conditions:**
There is a moving event e
The movers are the agents of e
The pianos are the themes of e

The predicted weak truth-conditions, as revealed by the negative version of the sentence, are less satisfactory however.

[27] From this remark, we can also conclude that while type-wise appropriate, the use of a ** operator on this evt predicate, as introduced in Beck (2012), would not generate the missing cumulative reading.

[28] A diligent reader may run the computations to see what reading does obtain with DIST or with a plural indefinite. The generated reading is doubly-distributive in each case, the only reading of the sentence.

(62) a. The movers didn't carry the pianos upstairs.

b. **Truth-conditions:**
not[there is a moving event e
some of the movers are the agents of e
some of the pianos are the themes of e]

To see this, consider (62a) in the scenario below, which is isomorphic to Križ (2016)'s scenario 3 (p. 518).

(63) **Outside help**
One mover and one inhabitant of the building carried some of the pianos upstairs together

The sentence in (62a) is not judged true in this context (as reported by Križ on his version of the sentence) and this is what Križ refers to as Sidewards Homogeneity. Problematically, the sentence is predicted to come out true in the current framework, simply because the only events of carrying which happened in **Outside Help** did not involve a sub-part of the movers as its agents, satisfying (62b)'s requirements.

To remedy this, we may consider changing the notion of participation that appears in the weak truth-conditions, replacing subsethood with overlap[29], as in (64a). And indeed, the notion of overlap is sometimes used in trivalent work on homogeneity (Križ, 2017).

(64) a. $[\![\text{Agent}]\!](x)(p)(e) = \mathsf{true}$ iff $p(e)$ and $\mathsf{agent}(e) = x$
"*x is the agent of some p-event e*"
$[\![\text{Agent}]\!](x)(p)(e) \neq \mathsf{false}$ iff $p(e)$ and for some Y overlapping X, $\mathsf{agent}(e) = Y$

b. **Predicted truth-conditions of (62a):**
not[there is a moving event e
the agents of e overlapped with the movers
the themes of e overlapped with the pianos]

But these truth-conditions come out too strong. For instance, they come out false in the scenario (65a), because of the existence of the event e_0 described in (65b). Yet, (62a) is true in that context.

(65) a. **To each their own**
The movers carried the chairs upstairs.
The inhabitants carried the pianos upstairs.
No other carrying happened.

b. Event e_0 of carrying.
The agents of e_0 are the movers and the inhabitants.
The themes of e_0 are the chairs and the pianos.

[29] A plurality X overlaps Y just in case there is a part of X that is also a part of Y.

To get a weaker reading of (65) then, we need a stronger notion of overlap. I suggest that the correct notion of participation is "*overlap with all subparts*". Compositional details aside for the moment, the truth-conditions associated to this new notion are as in (66).

(66) **Predicted truth-conditions:**
not[there is a moving event e
$\forall e' \prec e$, the movers overlaps with the agents of e'
$\forall e' \prec e$, the pianos overlaps with the themes of e']

This notion of participation is slightly weaker than subsethood but not so weak as overlap. As a result, it correctly predicts scenario **Outside Help** to be not true and **To Each Their Own** to be true. In the **Outside Help** scenario for instance, the event e_0 containing the inhabitant and the mover carrying one piano upstairs has only itself as a sub-event. The movers overlap with the agents of e_0 and, concomitantly, all sub-events of e_0. The pianos do as well. So the truth-conditions of the sentence are falsified: the sentence is not true. It is in fact undefined.

Similarly, scenario **To Each Their Own** is predicted to be true. Contrary to the simple notion of overlap, the large event e_0 described in (65b) here does not falsify the truth-conditions in (66). Indeed, this event e_0 contains an event e_1 of the inhabitants carrying the pianos. The agents of that sub-event do not overlap with the movers ; thus they do not falsify the conditions specified by the truth-conditions.

All there remains to do is to wire this notion of "*overlap with all subparts*" in the meaning of thematic role heads ; this is done in (67):

(67) $[\![\text{AGENT}]\!](x)(p)(e)$ is true iff $p(e)$ and $\mathsf{agent}(e) = x$
"*x is the agent of some p-event e*"
$[\![\text{AGENT}]\!](x)(p)(e)$ is true or undefined iff $p(e)$ and $\forall e' \prec e$, X overlaps with $\mathsf{agent}(e')$

This notion may seem remote from the notion of subset-hood we started with. However, note that in a context where no collective actions are ever performed, so that any event can always be broken down into a sum of events whose agents and themes are singularities, the two notions coincide. Since this is precisely the kind of sentences I have been careful to use in our discussion, none of our previous results are compromised by this addendum.

4.3 The elusive subject-inexhaustive readings

The analysis of articulated homogeneity proposed in this paper makes an interesting prediction: in the system, each of the thematic role heads contributes its own exhaustive inference: AGENT contributes S_{exh}, THEME contributes O_{exh}, etc. When *every* is introduced, it removes the homogeneity associated with the thematic role it bears, namely the homogeneity associated to O_{exh}. Thus, negating a cumulative sentence with *every* yields the reading $\neg O_{\text{exh}}$.

We may wonder whether it is possible to find a sentence where the homogeneity associated with the inference S_{exh} is suppressed. Negating that sentence would amount to negating that all the subjects participated in the action described by the subject. The type of sentence we are looking for would have the following shape:

(68) a. I doubt that *D* cooks opened the oysters

b. **Truth-conditions:**
not [every cook opened an oyster] (= $\neg S_{\text{exh}}$)

Few elements can fill the role of *D* in (68a). Placing *every* in subject position, for instance, will only yield a distributive reading, as we have seen ; it is not the right test case. The right test case would involve a homogeneity remover which does not impose distributivity to its scope.

all, which is also a homogeneity remover, for instance, carries some form of distributivity, just like *every*. In particular, in subject position, (Champollion (2017) (chap. 10), see also (Minor, 2017, sec. 1.4.1)) claim that *all* disallows cumulative reading (cf (69)). If this is so, then we cannot use *all* as our test case either[30].

(69) All the cooks opened twenty oysters.
$\rightsquigarrow$ *twenty oysters per cook*
$\not\rightsquigarrow$ *twenty oysters overall*

I propose to look at a different homogeneity remover instead: definite numerals in French[31]. These items display the homogeneity removing property that we are looking for: they exhibit a universal reading in positive sentences (cf (70a)) and a negative universal meaning under negation (cf (70b)).

(70) *Referring to a salient set of books that the speaker had to read...*

a. *J'ai lu les trois livres*
I-AUX read the three books

"*I read all three books*"

b. *Je n'ai pas lu les trois livres*
I NE-AUX not read the three books

"*I didn't read all three books*"

In addition, they behave like ordinary definite plurals in allowing collective interpretations:

[30] I have found some native speakers to dispute the judgment in (69) and allow for cumulative readings. It would be interesting to go to the bottom of this disagreement but caution commands that I do not use *all* as a homogeneity remover.

[31] This peculiarity of French was noted in Bar-Lev (2018); Križ (2016). The judgments reported come from four native speakers, the author excluded. There is indication that partitive numerals in English sometimes yield a similar reading.

(71) a. *Les trois déménageurs portent un piano*
The three movers carry.PRES a piano

Possible interpretation: "*The three movers are carrying a piano together*"

b. *Les trois lampes coûtent 100€*
The three lamps cost.PRES 100€

Possible interpretation: "*taken together, the three lamps cost 100€*"

This item seems adequate for the purpose of finding a sentence where the homogeneity of S_{exh} is removed. All we have to do is to place this homogeneity remover in subject position of a cumulative clause in a negative environment:

(72) *Je doute que les trois cuisiniers aient ouvert les huîtres.*
I doubt that the thee cooks AUX.SUBJ opened the oysters

a. . . . *indeed, Lily was absent today.*

b. . . . *indeed, this oyster wasn't opened.*

Consultants judge continuation (72a) to be a justification of the speaker's doubts. Since continuation (72a) spells out a scenario where S_{exh} is false, this suggests that (72) is read as the negation of S_{exh}. Continuation (73b), on the other hand, does not confirm the speaker's doubts.

This data point goes in the direction of proving that the homogeneity effect associated to S_{exh} can be removed without removing the homogeneity effect associated to O_{exh}, confirming the formal separation between these two inferences. However, the interpretation of this datapoint is subject to caution, since the homogeneity-removing effect of "*the 3*" in French is not properly understood and concomitantly, not captured by the current system.

4.4 Summary

In this section, I discussed three ways in which the analysis may be expanded. I discussed the asymmetries in cumulative readings of *every*. I showed that Kratzer's denotation was able to contend with the c-command generalization of Champollion (2010). I then proceeded to amend the definition of the gap in thematic role head so as to explain the truth-value gaps found in transitive collective sentences (i.e. Križ's Sidewards Homogeneity), a missing ingredient in the analysis so far. Finally, the subject-inexhaustive readings of French's definite numerals provided the missing counterpart to the object-inexhaustive readings studied until then.

5 Comparisons

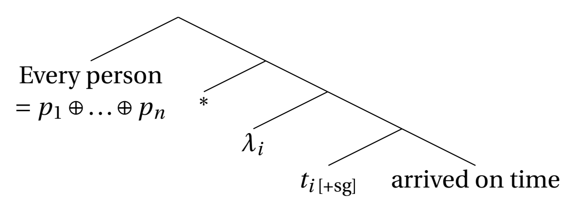
In this section, I discuss three proposals on cumulative readings of *every*: Champollion (2010), Haslinger and Schmitt (2018) and Champollion (2016a). The goal of this discussion will be to see whether the homogeneity facts discussed in section 1 can be accommodated in each of these systems. Most of these systems do not model homogeneity in the first place and thus, I will lead the discussion following what I believe is the most natural way to incorporate homogeneity in these proposals. With this methodology, I find that only Champollion (2016a), whose system is close to Kratzer (2000), and which critically assumes thematic role separation, can straightforwardly accommodate the facts presented here. As the conclusions drawn depend on the particular implementation of homogeneity which I assume for a given analysis, the conclusions drawn will be limited in scope. It may be that the works which cannot currently capture the homogeneity facts under the implementation I chose can in fact do so under alternative implementations. Nevertheless, the failures of Champollion (2010); Haslinger and Schmitt (2018) to account for the homogeneity facts under natural implementations of homogeneity is instructive: it shows that cumulative readings of *every* cannot be considered independently of homogeneity, because assumptions about cumulative readings of *every* will entail predictions on homogeneity facts.

5.1 Without events

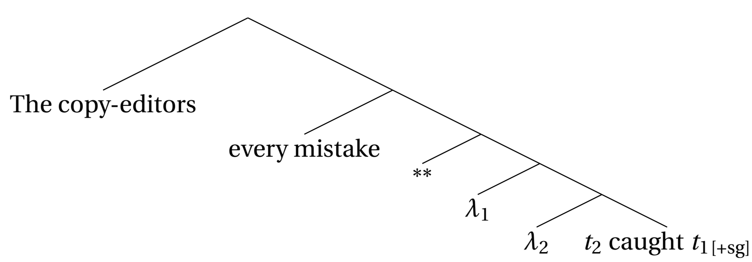
5.1.1 Champollion (2010)

Champollion (2010)'s proposal for cumulative readings of *every* is radically simple. In his view, *every child* denotes the plurality of children. However, its trace must be interpreted as a singular, for syntactic reasons. The only way out of these conflicting requirements is for some distributivity operator to intervene between "*every child*" and its trace. This accounts for *every*'s distributive properties. Being a plural, *every child* can enter cumulative relations with other elements using Beck and Sauerland (2000)'s ** operator.

(73) a. The simple case



b. The cumulative case:



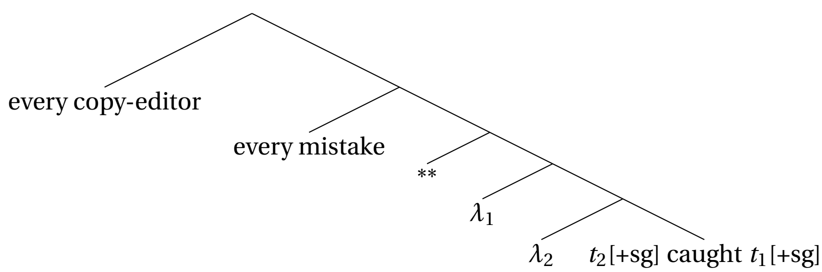
The elegant simplicity of the theory is appealing. There are however some glitches. In this theory, two *every*'s can get a cumulative reading, through the LF in (75), contrary to fact.

(74) a. Every copy-editor caught every mistake.

b. **Predicted:** every editor caught a mistake *and* every mistake was caught by an editor.

c. **Actual:** every copy-editor caught every mistake

(75)



If this problem can be overcome, the question of how homogeneity interacts with this system remains, specifically how one may capture the contrast between (76a) and (76b):

(76) a. I doubt the copy-editors caught every mistake
⇝ I think that some mistake wasn't caught by any of the editors.

b. I doubt that the copy-editors caught the mistakes
⇝ I think that no mistake was caught by any of the editors.

To incorporate homogeneity in the system, one could for instance take ** to be the locus of homogeneity. Modeling the truth-value gap of ** after the truth-value gap of ordinary cumulative sentences, the following trivalent denotation could be offered[32]:

(77) $$[\![**]\!](R) = \lambda X.\lambda Y.\begin{cases} 1 & \text{if for every } x \text{ in } X\text{, there is a } y \text{ in } Y\text{, such that } R(X)(Y) \\ & \quad \text{for every } y \text{ in } Y\text{, there is a } x \text{ in } X\text{, such that } R(x)(y) \\ \neq 0 & \text{if there is some } x \text{ in } X\text{, there is a } y \text{ in } Y\text{, such that } R(x)(y) \end{cases}$$

According to Champollion (2010), the LFs of (76a) and (76b) will only differ in what the relation R that ** applies to is. For the case of cumulative reading of *every*, R(X)(Y) can only be true if Y is a singularity ; for ordinary cumulative reading, no such restriction applies. Whenever Y is a singularity, the two relations will yield the same truth-value.

However, this difference between the relations that ** applies to in both cases does not make *enough* difference ; both sentences are predicted to have the same truth-value gap. Indeed, as per the denotation in (77), they will both be # if one copy-editor x found one mistake y and no other mistakes were found.

[32]This is a simplification, as the proposed denotation rules out collective predication.

One could consider the possibility of hard-wiring some form of homogeneity-removal in the semantics for *every*, as proposed in section 3.4 for other quantifiers. Most straightforwardly, one could assume *every* co-occurs with the assertion operator A. Unfortunately, A will indiscriminately erase all the truth-value gap introduced by the ** operator[33]; yet, we do want to predict that (78) has a truth-value gap.

(78) The copy-editors caught every mistake.

The conclusion that arises from this discussion is that to account for the homogeneity facts, Champollion (2010) would require an A operator that can discriminate between the "*subject gap*" and the "*object gap*" and be able to cancel the latter but not the former. Note that this separation between the two types of gaps is exactly what the articulated system for homogeneity in cumulative sentences is intended to derive.

5.1.2 Haslinger and Schmitt (2018)

Haslinger and Schmitt (2018) proposes an event-free analysis of cumulative readings of *every*. Their analysis is embedded in the framework of cross-categorial pluralities of Schmitt (2013, 2015). In this framework[34], any type has a corresponding plural type: there are plural predicates, plural propositions, etc. The denotation of *every* that Haslinger and Schmitt propose forms a plurality of predicates from each quantificational case of *every*. For instance, *patted every cat* will denote the plurality in (79).

(79) $[\![\text{patted every cat}]\!] = \text{patted cat}_1 \oplus \ldots \oplus \text{patted cat}_n$ (=plural predicate)

The second ingredient is to hard-code the meaning of ** in the compositional rules ; they propose a rule of *cumulative functional application*[35]. This allows plural arguments higher in the syntactic tree to enter cumulative relations with the plurality of predicates created below by *every*. So (80a) and (80b) will combine to yield (80c):

(80) a. $[\![\text{caught every mistake}]\!] = \text{caught mistake 1} \oplus \text{caught mistake 2}$

b. $[\![\text{the copy-editors}]\!] = \text{copy-editor 1} \oplus \text{copy-editor 2}$

c. $[\![\text{the copy-editors caught every mistake}]\!]$
$= \text{the copy-editor 1 caught mistake 1} \oplus \text{the copy-editor 2 caught mistake 2}$
$\vee \text{the copy-editor 1 caught mistake 2} \oplus \text{the copy-editor 2 caught mistake 1}$
(by *cumulative functional application*)

[33]The blindness of A is not problematic in the context of the articulated system, since A can be taken to have scope only over the homogeneous thematic roles, as I assumed in section 3.4. This illustrates the main difference between the articulated system and the proposal sketched out here: one assumes a monolithic homogeneity-introducing object, the other has different homogeneity-introducer for different arguments.

[34]The system is in fact richer than my presentation here can do justice to. For full technical details, cf the original paper.

[35]My name, not theirs.

This correctly captures the cumulative reading. In addition, it gives a handle on the subject-object asymmetries: everything below *every* is interpreted in its scope, thus distributively. Only plural arguments higher in the tree can combine cumulatively with the plural predicate formed by *every*.

Both this analysis and the analysis presented here based on Kratzer (2000) consider that *every* creates a plurality at some level of composition: in the event-based analysis presented here, it is an ensemble event; in Haslinger and Schmitt (2018), a plural predicate. One interest of Haslinger and Schmitt (2018) is to get rid of the middle man in cumulative relations, the event structure.

How might homogeneity fit into the system? Haslinger and Schmitt (2018) do not discuss it explicitly. However, they assume that plural propositions are true if each of their atomic parts is, and false if none of them are (ex. 44). This means that truth-value gaps are predicted whenever a sentence denotes a non-atomic plural proposition. As far as I can tell, this assumption predicts the right truth/falsity-conditions on simple sentences. However, we must be cautious to not take this proposal too strongly. As the authors explain in footnote 13, this proposal for homogeneity is not final: "*we take it to be an open question [...] how best to account for homogeneity in cumulative sentences*". The authors do not say what motivates their suspicion regarding this account of homogeneity in cumulative sentences.

For want of an alternative solution, we may nevertheless wonder how this view of homogeneity might explain the contrast between (81a) and (81b). On its own, this view turns to not account form the contrast. Indeed, for Haslinger and Schmitt (2018), (81a) and (81b) are composed in similar ways. Both involve a lower plurality entering a cumulative relation with a higher plurality via cumulative function application. The only difference is that in (81a), the lower plurality is a plurality of entities; in (81b), it is a plurality of predicates. Both produce the plural proposition in (80c); it is thus expected that they would give rise to the same gap.

(81) a. The women patted the dogs.

b. The women patted every dog.

(82) a. The women didn't pat the dogs.

b. The women didn't pat every dog.

Adjustments to the cumulative composition rule would not remedy this problem: whatever changes are made to the cumulative functional application rule will affect both (81a) and (81b) in identical ways. The best option seems to be to encode some form of homogeneity removal in the meaning of *every*, as we discussed in section 3.4 in relation to other quantifiers than *every*. This is presumably desirable, since as it stands, the sentence in (83a) has the plural denotation in (83b), which should give rise to a truth-value gap, contrary to fact. Given the tight connection between plurality and homogeneity, the homogeneity-removal effect would effectively need to erase the plurality created by *every*. For instance, we could imagine that *every* converts the plural predicate in (79) to a grand conjunction as in (83c).

(83) a. I patted every cat.

b. $[\![(83a)]\!]$ = I patted cat$_1 \oplus \ldots \oplus$ I patted cat$_n$ (=plural predicate)

c. $[\![(83a)]\!] = (\text{patted cat}_1 \wedge \ldots \wedge \text{patted cat}_n)([\![\text{I}]\!])$ (=singular conjoined proposition)

This way of encoding homogeneity removal unfortunately goes counter to the account of cumulative readings. Indeed, the cumulative functional application rule only gives rise to cumulative readings if *patted every cat* is a plurality itself. Having collapsed the predicate into a grand conjunction, the underlying plural nature of the predicate *patted every cat* is lost and so is the cumulative reading. A doubly-distributive reading is generated.

Thus, the view of homogeneity sketched (but not fully endorsed) by Haslinger and Schmitt (2018) is not sufficient to account for the observed discrepancy between ordinary cumulative sentences and cumulative sentences with *every*. One must therefore seek an alternative theory of homogeneity compatible with this framework. The search space is constrained by the shape of the framework. For instance, the trivalent approach of Kriz (2015) is not straightforwardly adaptable to the plural framework of Haslinger and Schmitt (2018). This is because trivalence is an assumption about truth-values and the pluralities created by the plural framework live in a dimension above it (there exist plural truth-values, plural propositions, plural predicates). This makes it difficult to model a principled connection between undefinedness and pluralities.

The tentative conclusion to draw from this discussion is that Haslinger and Schmitt (2018) do not immediately account for the patterns of homogeneity in cumulative sentences. An alternative implementation for homogeneity is required and the choice of that implementation is not independent of the architecture that the plural framework assumes.

5.2 Within event semantics: Champollion (2016a)

Champollion (2016a) proposes an event denotation for *every* which, just like Kratzer (2000)'s, creates ensemble events that higher operators can combine with. Because he is interested in building unification between different cases of distributivity, his denotation for *every* (given in (84)) is more involved: not only is the event predicate an argument of *every* but the thematic role head is as well.

(84) $[\![\text{every NP}]\!] = \lambda\theta_{evt}.\lambda P_{vt}.\lambda e.\, \theta(e) = \bigoplus [\![\text{NP}]\!] \wedge e \in^* [\lambda e'.\, P(e') \wedge \theta(e') \text{ is an atom}]$

Let us see this denotation at work on some of our examples. In (85) for instance, *every* forms an ensemble event. In each event, only one of the cooks participated as an agent. It is then re-asserted that this ensemble event contains all the cooks as its agent.

(85) a. Every cook opened the oysters

b. $[\![\text{Every cook opened the oysters}]\!]$
$= \lambda e.\, [\![\textsc{Agent}]\!](e) = \bigoplus [\![\text{cook}]\!] \wedge e \in^* [\lambda e'.\, \mathsf{open}(e') \wedge [\![\textsc{Agent}]\!](e') \text{ is an atom}$
$\wedge \textsc{Theme}(e) = \iota\mathsf{oysters}]$

Just as with Kratzer's account, *every* can take a local scope within the VP, as in (86). When it scopes at this level, *every* creates an ensemble event containing, for every oyster, an event of opening that oyster. Because *open* is distributive on its object, this is the same as the denotation of the predicate "*opened the oysters*". Therefore, both will give rise to cumulative readings as expected

(86) a. The cooks opened every oyster.

b. $[\![\text{opened every oyster}]\!]$
$= \lambda e.\ [\![\textsc{Theme}]\!]\,(e) = \bigoplus [\![\text{oyster}]\!] \wedge e \in^{*} \left[\lambda e'.\ \mathsf{open}(e') \wedge [\![\textsc{Theme}]\!]\,(e') \text{ is an atom}\right]$
$= \lambda e.\ [\![\textsc{Theme}]\!]\,(e) = \bigoplus [\![\text{oyster}]\!] \wedge \mathsf{open}(e)$
$= [\![\text{opened the oysters}]\!]$

How are homogeneity effects understood in this system? Champollion (2016a) does not discuss them but since his denotation is close the one used by the present work, one may nevertheless hope that our explanation of the interaction between *every* and these effects would carry over to his system. The simplest way of bridging the two accounts would be to adopt the trivalent denotation of thematic roles from section 2.2 while maintaining Champollion (2016a)'s denotation for *every*.

The difference between Champollion's denotation for *every* and Kratzer's is that Champollion's denotation does not *only* quantify over singularities. This means that the homogeneity-removing effect of *every* must be explained otherwise. To see this, observe that in Champollion's denotation, repeated below in (87), the semantic contribution of the thematic role is duplicated (marked in red). One of its contributions is to assert that the ensemble event should only be composed of events where the relevant thematic role is atomic (the second one). As seen in section 2.2, the requirement of atomicity on our trivalent thematic role will cancel the homogeneity associated with θ. In its first contribution, the thematic role head modifies the ensemble event itself and asserts that the elements in the denotation of NP should stand in relation θ to the event. Because $\bigoplus P$ is a plural, that part of the meaning has a truth-value gap. In fact, that part of the meaning of *every* is the same meaning as obtained by combining a DP like "*the oysters*" with the thematic role head. As a result, the same type of homogeneity that "*opened the oysters*" gives rise to will arise in the case of "*opened every oyster*".

(87) $[\![\text{every NP}]\!] = \lambda\theta_{evt}.\lambda P_{vt}.\lambda e.\ \theta(e) = \bigoplus [\![\text{NP}]\!] \wedge e \in^{*} \left[\lambda e'.\ P(e') \wedge \theta(e') \text{ is an atom}\right]$

The fact that the homogeneity-removing effect of *every* does not "*come for free*" in this system may not be problematic ; as we saw in section 3.4, there is probably more to homogeneity removal in quantifiers than simply quantification over singularities. Champollion's system could simply assume, as I have done in section 3.4, that the denotation of *every* contains an A operator in the place where a gap might be reintroduced:

(88) $[\![\text{every NP}]\!] = \lambda\theta_{evt}.\lambda P_{vt}.\lambda e.\ A(\theta(e) = \bigoplus [\![\text{NP}]\!]) \wedge e \in^{*} \left[\lambda e'.\ P(e') \wedge \theta(e') \text{ is an atom}\right]$

As far as I can tell, this is a viable solution to the problem of homogeneity[36].

The conclusion of this discussion is that there are no major incompatibilities between the articulated system for homogeneity presented here and Champollion (2016a)'s proposal. This is expected as both work under similar Neo-Davidsonian assumptions.

Conclusion

In this paper, we investigated two related constructions: ordinary cumulative sentences and cumulative sentences with *every*. While similar in truth-conditions, these two types of sentences display different truth-value gaps. This, I argued, constitutes a unique insight into the composition of truth-value gaps. Specifically, I proposed that two homogeneous components of meaning S_{exh} and O_{exh} are specified in the AGENT and THEME thematic roles respectively. The homogeneity of each of these components may be canceled independently from the other. This account made correct predictions for *every* but also for quantifiers beyond *every* (section 3.4), in object or subject positions (section 4.1).

While I believe that the resulting view holds promise, this account needs to be completed with a more fleshed-out view of homogeneity. In this paper, I made use of Križ (2016)'s trivalent system for specifying homogeneity effects and Strong Kleene projection for combining the homogeneity effects of different sources. My use of Križ (2016)'s theory could be seen as a sort of "*black box*", in which the nature of the truth-value gap is left unanalyzed. As such, it could be embedded in a more substantive theory of homogeneity such as Bar-Lev (2018); Križ and Spector (2017); Malamud (2012). The only strong commitment of the system was to the Strong Kleene rule of projection. While arguably needed (Križ and Chemla, 2015), it remains to be seen whether the aforementioned proposals for homogeneity can actually accommodate that assumption or, if they can't, whether they can derive the particular combination of homogeneity associated with thematic role heads in some other way.

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[36] I thank a reviewer for pointing it out to me.

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