Cumulative readings of *every* do not provide evidence for events and thematic roles

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Abstract. An argument by Schein (1986, 1993) and Kratzer (2000) does not conclusively show that events and thematic roles are necessary ingredients of the logical representation of natural language sentences. The argument claims that cumulative readings of *every* can be represented only if at least agents are related to verbs via events and thematic relations. But scope-splitting accounts, which are needed anyway for noun phrases headed by *every* and other quantifiers, make it possible to represent cumulative readings in an eventless framework. While Kratzer regards the limited distribution of cumulative *every* as evidence for asymmetries in the logical representation of thematic roles, the empirical generalization on which she bases her reasoning is not the only plausible one. It looks more likely that *every* must be c-commanded by another quantifier in order to cumulate with it, no matter what its thematic role is.

1 Introduction

The question whether events and thematic roles are part of the logical representation of natural language sentences has been debated for over forty years. Early formal semantic work, as well as some modern authors, simply represents the meaning of verbs with n syntactic arguments as n-ary relations. A transitive verb, for example, is assumed to denote a two-place relation. Against this, Davidson (1967) argued that verbs denote relations between events and their arguments, so that a transitive verb denotes a three-place relation. Once events have been introduced, it becomes possible to see verbs as predicates over events, and to express the relationship between events and their arguments by separate predicates, i.e., thematic roles. This is the Neo-Davidsonian position (e.g. Parsons, 1990; Schein, 1993). Finally, Kratzer (2000) argues for an asymmetric position, according to which only agents are represented as thematic roles. The positions are illustrated in Table 1.

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Position	Verbal denotation	Example: Brutus stabbed Caesar
Traditional	$\lambda y \lambda x[stab(x,y)]$	$stab(b,c)$
Classical Davidsonian	$\lambda y \lambda x \lambda e[stab(e,x,y)]$	$\exists e[stab(e,b,c)]$
Neo-Davidsonian	$\lambda e[stab(e)]$	$\exists e[stab(e) \wedge agent(e,b) \wedge theme(e,c)]$
Asymmetric	$\lambda y \lambda e[stab(e,y)]$	$\exists e[agent(e,b) \wedge stab(e,c)]$

Table 1. A summary of the positions in event semantics

Over the course of the years, events and thematic roles have grown to be much more than mere notations.[1] For example, many theories that resort to the thematic role *agent* make specific claims about the semantic content of agenthood. But the choice between the representations in Table 1 has a more basic consequence. Because they use a larger number of relations, Neo-Davidsonian and asymmetric representations offer additional degrees of freedom. They make it possible to codify meanings in which one argument modifies a different event variable than the verb does. Such configurations are impossible to write down without the help of thematic roles, regardless of their precise semantics. Schein (1993) calls the property of such sentences *essential separation*.

The argument presented in Schein (1993) and – in reformulated and extended form – in Kratzer (2000) holds that cumulative readings of *every* involve essential separation. My goal is to refute this specific argument by showing how these readings can, in fact, be adequately captured using an eventless representation that does not use explicit roles. The crux of the argument bears on how the meaning of *every* is adequately represented. There are many ways to adapt eventless frameworks to the task at hand; see Brasoveanu (this volume) for a dynamic framework. I will stay close to the framework used in Kratzer (2000) in order to make the comparison as easy as possible. I will focus on the parallels with existing approaches to quantification, rather than on technical aspects.

Following Kratzer, I use the algebraic semantic framework of plurals introduced in Link (1983).[2] Since Schein not only argues for events and thematic roles

[1] In this paper, I talk of models and logical representation languages only for convenience. I don't make any ontological claims about their existence. Readers who doubt that we should ascribe existence to models or logical representation languages in the first place should interpret the claims about whether events and thematic roles "exist" as claims about whether natural language is rich enough to express meanings which, if we choose to represent them formally, go beyond what can be expressed without using notational devices such as event variables and thematic relations.

[2] In algebraic frameworks, the domains of individuals and, if present, of events are each partially ordered by a mereological *part-of* relation $\sqsubseteq$. On the basis of $\sqsubseteq$, an operation $\oplus$ is defined that maps entities onto their *sum*, or least upper bound. $\sqsubseteq$ orders the domains of individuals and events each into a complete join semilattice; in other words, the sum operation is defined for arbitrary nonempty subsets of these domains. Singular common nouns denote predicates over atomic individuals (individuals that have no parts); plural common nouns hold of sums. The pluralization operator, written *, closes predicates P under sum, i.e. $^*P$ is the smallest set such that (i) if

but also, separately, against Link's framework, let me briefly justify my choice. As Schein points out, his two arguments are logically independent of each other, so his argument for events and roles can be recast in mereological terms, and this is in fact what Kratzer (2000) does.[3] I have two reasons for following her example. First, this makes it easier to compare my approach to Kratzer's. Second, I will argue that cumulative readings of *every* can be modeled using standard accounts of cumulative readings such as Krifka (1986) and Sternefeld (1998), and these accounts happen to be formulated in Link's algebraic framework. That said, choosing Link's framework is not essential for my purposes as long as the domain of individuals is grounded in *atoms* or individuals that have no parts. Under this standard assumption, join semilattices are isomorphic to an appropriate kind of set-theoretic lattice; see Schwarzschild (1996) for an example. So everything I say about individuals can be reformulated without the use of a mereological framework.

2 Schein and Kratzer's Argument

Schein's original argument is very intricate and relies on complicated sentences involving three quantifiers. I will discuss these sentences later. Here, I summarize and address Kratzer's simplified exposition of his argument. It is based on the following sentence:

Example 1. Three copy editors caught every mistake in the manuscript.

Kratzer claims that (1) has a reading that can be paraphrased as "Three copy editors, between them, caught every mistake in the manuscript." In this reading, there are three copy editors, each of them caught at least one mistake, and every mistake was caught by at least one copy editor.[4] If the subject DP is understood distributively, neither the surface scope reading ("Each of three copy editors caught every mistake") nor the inverse scope reading ("each mistake is such that it was caught by each of three copy editors") is equal to Kratzer's reading, because unlike it, they both entail that each mistake was caught by more than one copy editor. One possible line of analysis would be to claim that in Kratzer's reading, the subject DP is understood collectively, so that any mistake that is caught by one of the editors counts as being caught by all three of them collectively (a "team credit" analysis). But, she argues, sentence (1) is true even if the editors worked independently of each other, which is incompatible with

$P(X)$ then $^*P(X)$; (ii) if $^*P(X_1)$ and $^*P(X_2)$ then $^*P(X_1 \oplus X_2)$. For more details, see e.g. Link (1998).

[3] Schein's argument against sums is based on Russell's paradox. For a rebuttal of this argument, see (Link, 1998, ch. 13).

[4] Not all native speakers I consulted report that Kratzer's reading is in fact available from (1), though it seems present for everybody in the paraphrase that adds *between them*). In the following, I will grant that Kratzer's factual claim about (1) is correct. In any case, it is possible that her argument could also be based on the paraphrase, once the semantics of *between them* has been worked out.

the usual understanding of the collectivity notion. In particular, (1) entails that every copy editor found at least one mistake, while collective readings do not always license this entailment. For additional arguments against a team-credit analysis, see Bayer (1997). For these reasons, I will not rely on team credit.

My strategy consists in analyzing Kratzer's reading as a cumulative reading, the kind of reading which occurs in *600 Dutch firms own 5000 American computers* (Scha, 1981). It expresses that there are 600 firms and 5000 computers, each firm owns at least one computer, and each computer is owned by at least one firm. Following Krifka (1986) and Sternefeld (1998), this reading can be represented as follows, without events or thematic roles:

Example 2. $\exists X.\ [\text{600-firms}(X)\ \wedge\ \exists Y.\ [\text{5000-computers}(Y)\ \wedge\ {}^{**}\text{own}(X,Y)]]$.

This representation makes use of the following ingredients and conventions. Uppercase letters are used for variables and constants that denote either atoms or sums, and lowercase letters for those that denote atoms. I use shorthands for the noun phrase denotations: for example, the predicate *600-firms* is true of any sum of firms whose cardinality is 600. The *cumulation* operator **, a generalization of the pluralization operator from footnote 2, has been defined in various ways in the literature (see e.g. Beck and Sauerland, 2000). The definition I use is from Sternefeld (1998): Given a complete join semilattice $\langle S, \sqsubseteq \rangle$ and a binary relation $R \subseteq S \times S$, ${}^{**}R$ is the smallest relation such that (i) if $R(X,Y)$ then ${}^{**}R(X,Y)$; (ii) if ${}^{**}R(X_1,Y_1)$ and ${}^{**}R(X_2,Y_2)$ then ${}^{**}R(X_1 \oplus X_2, Y_1 \oplus Y_2)$.

Cumulative readings express information about the cardinalities of the minimal witness sets associated with the quantifiers involved (Szabolcsi, 1997). Standard representations of *every* have problems with this kind of configuration (Roberts, 1987). For example, interpreting "every mistake" in situ as $\lambda P.\forall x.\text{mistake(x)} \rightarrow P(x)$ leads to the interpretation in (3). But this is just the surface scope reading. The problem arises because "every mistake" does not provide a handle on its witness set, i.e. the set containing every mistake.[5]

Example 3. $\exists Y.[\text{three-copy-editors}(Y)\ \wedge\ \forall x.[\text{mistake}(x) \rightarrow {}^{**}\text{catch}(Y,x)]]$

As Schein and Kratzer observe, if we adopt a Neo-Davidsonian position, the cumulative reading can nonetheless be represented adequately. Their idea is that once we have the agent role at our disposal, we can represent (1) roughly as "There is a sum of mistake-catching events E, the agents of these events amount to a sum X of three editors, and every mistake was caught in at least one of these events", as in (4):

Example 4. $\exists E\ \exists X\ [\text{three-copy-editors}(X)\ \wedge\ {}^{**}\text{agent}(E,X)$
$\wedge\ \forall y\ [\text{mistake}(y) \rightarrow \exists e\ [e \sqsubseteq E\ \wedge\ \text{catch}(e,y)]]$
$\wedge\ \exists Y\ [{}^{*}\text{mistake}(Y)\ \wedge\ {}^{**}\text{catch}(E,Y)]]$

Following Schein, Kratzer takes this fact to show that we need to have at least the relation *agent* at our disposal in our logical representation.

[5] The ** operator makes sure that the cumulated relation applies to every member of the two sums. Here, it enforces that each of the three editors was involved in catching mistakes. This avoids the "leakage" problem of the account in Bayer (1997).

3 Modeling Cumulative *every* Without Events

Schein and Kratzer's argument is based on the assumption that the adequate translation of *every mistake* is in terms of a universal quantifier. The difficulty arises from the fact that the cumulative reading of (1) expresses something about the set or sum of all mistakes. But the universal quantifier does not give us a handle on this object, because it holds of any set that contains every mistake and possibly some non-mistakes.

The first step towards a solution was taken in Landman (2000), who claimed that *every mistake* can shift to a referential interpretation, one that denotes the sum or group of all mistakes, written $\sigma x.\text{mistake}(x)$.[6] On this view, *every mistake* is synonymous with *the mistakes*, if we disregard the fact that the latter sometimes allows nonmaximal interpretations (Krifka, 1996; Malamud, 2006). At first sight, this suggestion faces an obvious problem: The distribution of *every mistake* is more restricted than the one of *the mistakes.* As is well known, *every* forces distributivity over its argument position:

Example 5. a. #Every soldier surrounded the castle. *(only distributive)*
b. The soldiers surrounded the castle. *(distributive or collective)*

This problem can be overcome by assuming that the restrictor of *every* is interpreted both in its base position as a restriction on the values of its argument position, and above the cumulation operator, where it is the input to sum formation.[7] Evidence that supports this assumption comes from two strands of research. A growing body of literature suggests that the syntax of *every N*, and of quantified nominals in general, breaks down into two components; in the case of *every N*, one component expressing exhaustivity and one expressing distributivity.[8] For example, according to Szabolcsi (1997), noun phrases headed by *every* consist of an exhaustive and a distributive component, which can take scope separately under limited conditions. That the restrictor of quantifiers should be interpreted both in situ and in the scopal position fits well within the general picture suggested by reconstruction effects, i.e. effects in which part of the lexical content of moved phrases is semantically interpreted in its base position. Reconstruction effects involving both *every* and other A'-moved items are well

[6] Alternatively, the shift could be to a predicative interpretation, one that holds precisely of the sum of all mistakes. This solution is independently needed for variants *every other* and *almost every* which do not have a unique minimal witness. It could be exploited for explaining in terms of type mismatch why *every* is never interpreted in situ. For clarity of exposition, I stick to the referential interpretation of *every.*

[7] The granularity of *every* is determined by its complement and not by atomicity, as pointed out by Schwarzschild (1996), using examples like *Every three houses formed a block.* Here, quantification is over sums of three entities, not over atomic entities. So the level of granularity is sensitive to the restrictor of *every.*

[8] To name just a few: Ruys (1992), the papers in Szabolcsi (1997), Matthewson (2001); Sauerland (2003, 2004); Kratzer (2005); Johnson (2007); Abels and Marti (2009).

documented in various constructions. Examples are binding theory (Chomsky, 1993; Fox, 1999) and antecedent-contained deletion (Sauerland, 2004).

Abstracting away from details, the insight I take from this work is that the exhaustive component of *every* (the one that refers to the sum entity) corresponds to its higher scopal position, and the component that corresponds to its restrictor is interpreted both in its higher and lower scopal position.

Technically, the concept that restrictors of quantifiers are interpreted in several places can be expressed in any number of ways: syntactically, for example, by creating multiple copies of phrases (Engdahl, 1986; Chomsky, 1993) or multiply dominated phrases (Johnson, 2007); or semantically, by encapsulating the contribution of the restrictor into objects that the interpretation function makes accessible in several places, such as choice functions (Sauerland, 2004) or sets of assignments (Brasoveanu, this volume). Rather than comparing all these approaches, I simply choose the proposal with the lowest types and the least departure from ordinary syntactic assumptions, both for lack of space and because this makes the interaction with the cumulation operator easier to grasp. I adopt the proposal by Fox (1999, 2002), according to which in situ copies are interpreted by a special semantic rule, shown here in simplified form:

Example 6. Trace Conversion Rule: $[\![(\text{Det})\ \text{N}]_x]\!] = \iota y.[[\![\text{N}]\!](y)\ \wedge\ y = x]$

With Trace Conversion, the lower copy of a DP *every N* which bears the index x is interpreted as "the N which is x". The contribution of the determiner in the lower copy is ignored. The distributivity of the quantifier is modeled by a star operator. I also assume that all quantifiers (even those in subject position) move before they are interpreted, so that trace conversion always applies. On *three copy editors*, the effect of trace conversion is vacuous, so I don't show it.[9]

As an example, "Every dog barks" is interpreted as in (7). Here and below, the parts contributed by "every N" are underlined.

Example 7. $\underline{\sigma x.\ \text{dog}(x)} \in {}^{*}\lambda X\ [\text{barks}(\underline{\iota x'.\text{dog}(x')\ \wedge\ x' = X})]$

The cumulative reading of (1) can be represented as follows:

Example 8. $\exists X\ [\text{three-copy-editors}(X) \wedge$
$\langle X, \underline{\sigma y.\ \text{mistake}(y)}\rangle \in {}^{**}\lambda X' \lambda Y\ [{}^{**}catch(X', \underline{\iota y'.\text{mistake}(y')\ \wedge\ y' = Y})]]$.

This is provably equivalent to Kratzer's representation in (4), provided that $catch(x, y)$ holds whenever $\exists e\ [agent(e, x) \wedge catch(e, y)]$ and that (at least) the second argument of *catch* is always atomic.[10] Note that the requirement that Y range over singular mistakes effectively restricts it to atomic values.

[9] Alternatively, one can assume in the style of Matthewson (2001) that *every N* is interpreted as a covert variant of the partitive construction *each of the Ns*, and furthermore that *the Ns* can raise out of that construction to take part in a cumulative relation. This way, subject quantifiers can be interpreted in situ.

[10] This assumption is independently necessary to model the fact that if two mistakes A and B get caught, this always implies that A gets caught and B gets caught. It is necessary for the proof because Kratzer's representation in (4) does not actually exclude the technical possibility that the sum event E contains some catching events in which a sum of mistakes gets caught whose parts do not get caught individually.

4 Mixed Cumulative-Distributive Readings

The sentences originally discussed by Schein (1993) are more complicated than Kratzer's in two respects. First, they involve nonincreasing numeral quantifiers such as *exactly two*. When these quantifiers occur in cumulative readings, the formulation of their maximality conditions requires special attention, but this is true no matter whether events and thematic roles are used (von Benthem, 1986; Krifka, 1999; Landman, 2000; Robaldo, 2009; Brasoveanu, this volume). Second, the sentences exhibit mixed distributive-cumulative configurations, such as in the following example:

cumulative

Example 9. [$_A$ Three video games] taught [$_B$ every quarterback] [$_C$ two new plays].

distributive

The relevant reading of this sentence is the one in which there is a given set of three videos which between them were responsible for the fact that every quarterback learned two new plays. The solution from the previous section works here as well. We can represent the reading as in an eventless framework as follows:

Example 10. $\exists X$ [three-video-games(X)
$\wedge \langle X, \underline{\sigma y.\ \text{quarterback}(y)} \rangle \in {}^{**}\lambda X' \lambda Y$ [$\exists Z$ two-new-plays(Z)
$\wedge\ {}^{***}\text{taught}(X', \underline{\iota y'.\text{quarterback}(y') \ \wedge\ y' = Y}, Z)]]$

In this formula, the exhaustive component of "every quarterback" stands in a cumulative relation with "three video games", while its distributive component makes sure that *teach* relates individual quarterbacks to sums of two plays each. *** is the ternary equivalent of **. Two instances of cumulation are needed: the higher one to give *every quarterback* scope over *two new plays*, and the lower one to reflect the lack of scopal dependency between the three video games and any given set of two plays. This is because sentence (9) does not express for any set of two plays how many of the three video games taught that set.

5 Structural Asymmetries in Cumulative Readings

Recall that Kratzer's larger goal is to argue for a representation in which only the agent role, but not the theme role, is expressed as a separate relation. Kratzer is aware that the relevant reading of (1) can be described as a cumulative reading, but she prefers not to model it as such, observing that cumulative readings are less readily available with *every* in general.

Example 11. a. Every copy editor caught 500 mistakes in the manuscript.
b. 500 mistakes in the manuscript were caught by every copy editor.

Cumulative readings are absent from both examples in (11). In these examples, *every* is in agent position. Based on this, she generalizes that *every* can take part in cumulative readings only when it is not in agent position, cf. (1). This is indeed predicted by the asymmetry in her representation.

I doubt that Kratzer's generalization is the right one. Data cited in Zweig (2008) suggests that even when *every*-phrases do not denote the agent, they cannot always take part in cumulative readings. Zweig considers a scenario where "an international chess tournament is held between three teams from three countries: Estonia, Fiji, and the Peru. The tournament consists of a series of games, with no game played by two players from the same team. No draws or stalemates are allowed; the game is replayed until there is a winner. At the end of the day, it turns out that the Estonian team did very poorly: no Estonian won any games."

According to Zweig, it is true in this scenario to say (12a), while its passivized variant (12b) is judged as false. Native speakers uniformly judge that (12b), unlike (12a), implies that each game was won by both teams, an impossibility.

Example 12. a. The Fijians and the Peruvians won every game.
b. Every game was won by the Fijians and the Peruvians.

This minimal pair suggests that what blocks the cumulative reading of certain*every*-phrases is not their thematic role but the fact that they c-command the other quantifier. The following example from Bayer (1997) supports this.

Example 13. a. Every screenwriter in Hollywood wrote *Gone with the Wind*.
b. *Gone with the Wind* was written by every screenwriter in Hollywood.

For Bayer, (13a) is "clearly bizarre", which is compatible with Kratzer's prediction, as well as with the c-command constraint proposed here. But he reports that (13b) has a possible reading where every screenwriter in Hollywood contributed to the writing of the movie. Since *every* is in agent position in both cases, the asymmetry is unexpected on Kratzer's hypothesis.

6 Conclusion

Cumulative readings of "every" do not pose a special problem for eventless representations, contra Schein (1993) and Kratzer (2000). They do not constitute an argument that the logical representations of natural language sentences must make use of events or of thematic roles. The restriction on cumulative readings of "every" is more accurately stated in terms of c-command than in terms of thematic roles, so it is not an argument for the asymmetric account in Kratzer (2000). Of course, this does not exclude the possibility that events and thematic roles might be present in the linguistic system for other reasons. The claim here is simply that cumulative readings of *every* do not bear on their status.

Further work is needed to explore and derive the c-command generalization. One option is to restrict the ** operator so that, outside of the lexicon, it only appears on syntactically plural verb phrases. This would be similar to the constraint proposed in Kratzer (2007), but it would not cover (13). The dynamic system in Brasoveanu (this volume) also derives the generalization, provided that cumulative *every* cannot take inverse scope. It remains to be seen whether this constraint can be maintained while permitting inverse scope of *every* in general.

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