Negation and distributivity in event semantics

A reply to Schwarzschild and Champollion*

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Abstract

Here I propose an interpretation of negation in event semantics that is compatible with the distributivity operators of Champollion 2016a and Champollion 2016b. This proposal is based on a distinction between two kinds of events: real ones and imaginary ones, the latter being only potentialities that never become reality. They allow to formally define negative events similar to the ones mentioned in Higginbotham 2009 and I show that (i) they obey the logic one would expect them to and (ii) they make it possible to compositionally derive the meaning of sentences such as *The kids each didn't eat an egg* ('none of them did').

1 Introduction

In a couple of papers (Champollion 2016a and Champollion 2016b), Lucas Champollion (henceforth 'LC') shows how distributivity operators could be modelled to successfully analyse sentences such as (1) in event semantics.

(1) a. The kids each saw two monkeys.
 b. The kids wore a black hat.

Independently, LC proposes in Champollion 2015 to include event existential quantification directly in the semantic entries of verbs. Doing so allows to easily get natural interpretations for the sentences in (2), involving a negated verb or a quantified argument (see the *event quantification problem*, Winter and Zwarts 2011).

(2) a. The kid ate every cake.
 b. The kid didn't eat the cake.

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As noted in Schwarzschild 2014[1], while those two sets of work both deal with somewhat related problems in event semantics, they use different approaches that seem incompatible. It appears indeed that in a sentence like (3), negation and distributivity interact in a particular way that cannot be captured without the introduction of new tools. I propose here to consider not only real (or 'actual') events but also imaginary (or 'non actual') ones, along with a certain interpretation of negation. This allows us to augment LC's sum distributivity approach to deal with negation.

(3) a. Three kids each did not eat an egg.
  b. (meaning *There are three kids none of which ate any egg.*)

In section 2 I present the particularities of the event semantics I use. In section 3 I show that those particularities don't break the basic logical properties of the system. In section 4 presents a treatment of negation that interact in a natural way with LC's distributivity operators.

2 Modifications to the logical language and the interpretation of the models

Let's add to the logical language:[2]

- a predicate symbol $Real : v \to t$;
- a function symbol $Neg : (v \to t) \to v$ (denoting a function from sets of events to events).

The purpose of the *Real* predicate is to indicate that a given event is real. Indeed, in the ontology I propose, events need not correspond to the reality, and a sentence such as (4) states not only that there exists an event of rain, but also that this event is real. The *Neg* function is used to construct *negative events*, such as in (5).[3] It seems that there may be multiple ways to conceive the (non-)reality of events; one is to see it as a primitive notion (the set of events being simply divided in the subset of real events and the subset of imaginary ones), another – expressed in possible world semantics terms – is that an event is real if and only if it exists in the actual world.[4] The present proposition does not require to commit to any particular view.

[1] Manuscripts were available prior to the years indicated in the references, so these are not anachronistic.

[2] In this document, I use the following standard notations of type theory: '$t : \alpha$' means that term t is of type α and $\alpha \to \beta$ is the functional type from α to β. The type of events is v, the type of individuals is e and the type of truth values is t.

[3] The meaning of sentence (5) is equivalently captured by $Real(Neg(\lambda e'.\ rain(e')))$, but it does not seem that such a formula can be generated easily in a compositional way, as opposed to (5b).

[4] In the latter case, it might be relevant to replace the *Real* operator with a relation between events and worlds, similar to the *Modl* operator of von Stechow and Beck 2015. Additionally, the axiom (1) below would have to be adapted accordingly.

(4) a. It is raining.

b. $\exists e.\ Real(e) \wedge rain(e)$

(5) a. It is not raining.

b. $\exists e.\ Real(e) \wedge e = Neg(\lambda e'.\ rain(e'))$

In order to get a correct interpretation of negation, I introduce the following axiom ensuring that a negative event is real iff all corresponding positive events are imaginary:[5]

$$\forall P : v \to t.\ Real(Neg(P)) \leftrightarrow (\forall e : v.\ Pe \to \neg Real(e)) \qquad (1)$$

With this axiom, (5) becomes equivalent to *there is no real event of rain*, a natural reading.

Remark 1: The idea of the *Neg* function comes from utterances such as (6), that show the necessity of reifying in the semantics some sort of negative events *if one is to represent causality as a relation between events*. The interpretation I defend is that one of the argument of the causal relation in (6a) is a not-raining event, and similarly in (6b) the pronoun *this* refers anaphorically to the not-raining event introduced in the first sentence. Related arguments were discussed in Higginbotham 1983 and Higginbotham 2009, but not provided with a fully formal account of negation. Please also note that the 'maximal fusion events' used in Krifka 1989 to deal with negation *cannot* serve as the negative events involved in (6). These maximal events do not depend on the predicates being negated and could only be interpreted as the negation of *all* predicates not being satisfied by any event during some given period of time; in other words, if it is neither raining nor snowing at time t, Krifka's proposition does not make any distinction between not raining and not snowing at time t.

(6) a. *John is happy* <u>because</u> **it is not raining**.

b. (It is not raining)$_i$. I have been waiting for this$_i$ way too long.

Remark 2: It is possible to extend a traditional event model (i.e. with no imaginary events) with a set of events E to a model with imaginary events in the following way:

1. let $E_{-1} = \emptyset$ and $E_0 = E \cup \{e'\}$, where e' is any object and for all $e \in E_0$ define $\texttt{Real}(e) = 1$ and $\texttt{Neg}(\emptyset) = e'$ (where $\texttt{Real}$ and $\texttt{Neg}$ will be the interpretations of respectively *Real* and *Neg* in the model being built);

2. for all $i \in \mathbb{N}$,

   - for all $S \in \mathcal{P}(E_i) \setminus \mathcal{P}(E_{i-1})$ consider e_S such as either (i) $e_S \notin E_i$ or (ii) $\texttt{Real}(e_S) = \begin{cases} 1 \text{ if } \forall e \in S,\ \texttt{Real}(e) = 0 \\ 0 \text{ otherwise} \end{cases}$, then define $\texttt{Neg}(S) = e_S$ and also $\texttt{Real}(e_S)$ as just mentioned in case (i);

[5] One also needs the axiom stating that a mereological sum of events is real only if all of its sub-event are also real, but I won't describe it here.

- define $E_{i+1} = E_i \cup \{e_S \mid S \in \mathcal{P}(E_i) \setminus \mathcal{P}(E_{i-1})\}$.

3. Continue the (transfinite) recursion on all ordinals.[6] Make sure that from some cardinal, only clause (ii) in step 2 is chosen.[7] Then define $E' = \bigcup_i E_i$.

E' is the event set of the new model and `Real` and `Neg` have been defined such that axiom (1) is respected and that all original events from E are real events; all other parameters (e.g. the interpretation of other constants) can be chosen at will.

3 Logical properties

Here I just check that basic logical properties involving negation are respected.

I start with double negation. For instance, one want (7a) and (7b) to be logically equivalent.

(7) a. Jane did not not eat an egg.
    b. Jane ate an egg.

Let P be any event predicate, then:

$$\begin{aligned} &\mathit{Real}(\mathit{Neg}(\lambda e.\ e = \mathit{Neg}(\lambda e'.\ Pe'))) \\ &\qquad \Leftrightarrow \forall e,\ e = \mathit{Neg}(\lambda e'.\ Pe') \to \neg \mathit{Real}(e) \\ &\qquad \Leftrightarrow \neg \mathit{Real}(\mathit{Neg}(\lambda e'.\ Pe')) \\ &\qquad \Leftrightarrow \exists e'.\ Pe' \wedge \mathit{Real}(e') \end{aligned} \tag{2}$$

Now I turn to logical entailments of the form (8a) $\Rightarrow$ (8b).

(8) a. Jane didn't eat.
    b. Jane didn't eat an egg.

$$\begin{aligned} &\mathit{Real}(\mathit{Neg}(\lambda e.\ \mathit{eat}(e) \wedge \mathtt{Ag}(e, \mathit{Jane}))) \\ &\qquad \Rightarrow \forall e,\ (\mathit{eat}(e) \wedge \mathtt{Ag}(e, \mathit{Jane})) \to \neg \mathit{Real}(e) \\ &\qquad \Rightarrow \forall e,\ (\mathit{eat}(e) \wedge \mathtt{Ag}(e, \mathit{Jane}) \wedge \exists x.\ \mathit{egg}(x) \wedge \mathtt{Th}(e,x)) \to \neg \mathit{Real}(e) \\ &\qquad \Rightarrow \mathit{Real}(\mathit{Neg}(\lambda e.\ \mathit{eat}(e) \wedge \mathtt{Ag}(e, \mathit{Jane} \wedge \exists x.\ \mathit{egg}(x) \wedge \mathtt{Th}(e,x)))) \end{aligned} \tag{3}$$

[6] Step 2 only needs to differ for limit ordinals α (in place of $i+1$), by considering S in $\mathcal{P}(\bigcup_{j<\alpha} E_j) \setminus \bigcup_{j<\alpha} \mathcal{P}(E_j)$, on clause (i) e_S not in $\bigcup_{j<\alpha} E_j$ and defining E_α as $\bigcup_{j<\alpha} E_j \cup \{e_S \mid S \in \mathcal{P}(\bigcup_{j<\alpha} E_j) \setminus \bigcup_{j<\alpha} \mathcal{P}(E_j)\}$.

[7] Choosing clause (i) too often would make $\bigcup_{j\leq i} E_j$ grow so much that $\bigcup_i E_i$ would be a proper class (i.e. not a set). Consistently choosing clause (ii) whenever possible leads however to the addition of only 1 or 2 elements to the initial E (depending on whether e' was selected in E or not in step 1).

4 Distributivity on negative events

Here is the semantic interpretation of adverbial *each* given in Champollion 2016b.

$$[\![\text{each}]\!]_\theta = \lambda V e.\ e \in {}^*\lambda e'.\ atom(\theta(e')) \wedge V e' \tag{4}$$

Here I define the semantic interpretation of adverbial negation and the closure term. Note that as adverbial *each*, the adverbial negation requires a parameter of type $v \to t$; this parameter is constrained to be the θ-role of the subject of the verb it scopes over.[8,9]

$$[\![\text{not}]\!]_\theta = (\lambda V e.\ e = Neg(\lambda e'.\ \theta e = \theta e' \wedge V e')) \tag{5}$$

$$closure = \lambda V.\ \exists e.\ Real(e) \wedge V e \tag{6}$$

Here is the semantic interpretation of *didn't eat an egg*:

$$\begin{aligned}[\![\text{didn't eat an egg}]\!] &= [\![\text{not}]\!]_{\texttt{Ag}}[\![\text{eat an egg}]\!] \\ &= (\lambda e.\ e = Neg(\lambda e'.\ \texttt{Ag}(e) = \texttt{Ag}(e') \wedge {}^*eat(e') \wedge an\_egg({}^*\texttt{Th}(e'))))\end{aligned} \tag{7}$$

And for (3) (repeated below as (9)) (after closure):

$$\begin{aligned}&[\![\text{Three kids each didn't eat an egg.}]\!] = \\ &\qquad \exists e.\ Real(e) \wedge three\_kids({}^*\texttt{Ag}(e)) \\ &\qquad\qquad \wedge\, e \in {}^*\lambda e'.\ atom(\texttt{Ag}(e')) \wedge [\![\text{didn't eat an egg}]\!] e'\end{aligned} \tag{8}$$

This implies that for each of the three kids x, there exists a real event e' such that $\texttt{Ag}(e') = x \wedge [\![\text{didn't eat an egg}]\!] e'$, which implies that no event consisting of x eating an egg is real.

(9) (=(3))

a. Three kids each did not eat an egg.

b. (meaning *There are three kids none of which ate any egg.*)

[8] This only applies when there is an explicit subject in the sentence and when this subject is associated with a θ-role. Otherwise – as in *it is raining* –, an 'empty' (or dummy) θ-role is used, i.e. a meaningless function θ_0 that assigns the same constant to all eventualities ($\forall e, e'.\ \theta_0(e) = \theta_0(e')$); alternatively, a parameterless term $[\![\text{not}]\!] = (\lambda V e.\ e = Neg(\lambda e'.\ V e'))$ can be added to the lexicon.

[9] The idea behind the θ-parameter is that the Neg function must scope over an exact description of the predicate one wants to negate. Because the subject is out of the syntactic scope of negation while it carries information that should still be part of the predicate negated, some particular device is required (otherwise, in most cases a negative sentence will be interpreted as stating the non-reality of too many events). The θ-parameter does exactly this and the only rule governing its assignation (always the θ-role of the subject) seems satisfactorily simple and systematic. In addition, please note that in the case of a transitive verb, for example, the information about the object is already under the scope of the negation and thus no further parameter is required.

5 Conclusion

The interpretation proposed here, based on a distinction between real and imaginary events allows one to reconcile negation with mereological treatments of distributivity. It has also the advantage of making negative non-P events available as first-class citizens of the semantics, which is not usually the case of other accounts of negation in event semantics, be they formulated in a mereological setting (Krifka 1989) or not (de Groote and Winter 2014, Champollion 2015).

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