The interaction of compositional semantics and event semantics

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Abstract

Davidsonian event semantics is often taken to form an unhappy marriage with compositional semantics. For example, it has been claimed to be problematic for semantic accounts of quantification (Beaver and Condoravdi, 2007), for classical accounts of negation (Krifka, 1989), and for intersective accounts of verbal coordination (Lasersohn, 1995). This paper shows that none of this is the case, once we abandon the idea that the event variable is bound at sentence level, and assume instead that verbs denote existential quantifiers over events. Quantificational arguments can then be given a semantic account, negation can be treated classically, and coordination can be modeled as intersection. The framework presented here is a natural choice for researchers and fieldworkers who wish to sketch a semantic analysis of a language without being forced to make commitments about the hierarchical order of arguments, the argument-adjunct distinction, the default scope of quantifiers, or the nature of negation and coordination.

Keywords: event semantics, thematic roles, quantifiers, negation, coordination, for-adverbials

1 Introduction

Ever since Montague famously rejected the contention that there is any important theoretical difference between formal and natural languages, research on compositional semantics in his spirit has produced successful accounts of the behavior of scope-taking expressions (Montague, 1970). In particular, those expressions in natural language that have counterparts in predicate logic and related systems, such as quantifiers, negation, and conjunctions, have been given formal accounts. It has turned out in many cases that these counterparts, or suitable generalizations, are viable candidates for the formal representations of the core semantic meanings, and in particular of the scopal properties, of the relevant natural-language expressions. This can be seen, for example, in accounts of quantificational noun phrases in terms of generalized quantifiers (Barwise and Cooper, 1981), in accounts of truth-functional linguistic negation in terms of logical negation (Horn, 1989) and in accounts of coordination in terms of generalized logical conjunction and disjunction (Partee and Rooth, 1983). This is perhaps not surprising given that, historically speaking, the design of predicate logic was inspired by natural language.

Another successful tradition in semantics stems from Davidson's proposal that the logical form of action sentences makes reference to underlying events (Davidson, 1967). Building on this idea, semantic research has developed successful accounts of a large number of phenomena such as verbal modification, the relations between adjectives and adverbs, the relations between nominalizations, nominal gerunds, and verbs, the semantics of perception verbs, and the semantic relations between related members of semantic alternations such as causatives and inchoatives (Parsons, 1990, 1995).

I will call the two frameworks just mentioned "compositional semantics" and "event semantics". For the purpose of this paper, I take the advantages of each of these two frameworks to have been firmly established. The natural next question to ask is what is the best way to combine the two. This question is relevant for at least two kinds of addressees.

- The **theoretical researcher** may be primarily interested in interactions, such as whether a commitment to events implies or suggests a commitment to this or that analysis of a scope-taking expression – say, whether events require an analysis of quantifiers in syntactic terms and a commitment to a representational level distinct from surface form. I will argue that it does not, and I will present similar kinds of results in the case of analyses of negation and coordination.

- The **student** and the **semantic fieldworker** who wish to sketch an analysis of a language without making implicit semantic commitments about the difference between arguments and adjuncts may want to adopt event semantics because it provides the ability to treat them on par. They may also

> be interested in giving standard analyses of such commonplace phemonena as quantifiers and negation.

There is currently no consensus on what is the best way to combine compositional semantics and event semantics, whether it is possible or easy, and what consequences the presence of events has on the analyses of scope-taking expressions in compositional semantics. In many implementations of event semantics in compositional frameworks, accounts of scope-taking expressions such as quantifiers, negation, and conjunctions need to be complicated compared with the more standard treatments that would be available if events were not present. Perhaps for this reason, textbooks of compositional semantics tend to avoid using events (Heim and Kratzer, 1998). An aspiring semanticist or a fieldworker might be discouraged by this situation, particularly when a given language or phenomenon that seems to be well-suited to event semantics also involves scope-taking expressions that need to be analyzed in some way.

This paper aims to remedy this situation by presenting an implementation of event semantics that combines with standard treatments of scope-taking expressions in a well-behaved way. The implementation is then used to show that event semantics is compatible with the standard accounts of scope-taking expressions that have been developed in the tradition of Montague, and that the presence of events does not make it necessary to choose between accounts of these expressions in the way it has been claimed.

For example, there has been a long debate on whether the scope of quantificational arguments determined syntactically, for example by quantifier raising (May, 1985), or semantically, for example by type-shifting (Hendriks, 1993). It has been claimed more recently that adopting event semantics bears on this choice in a way that is not seen as advantageous. Thus, Beaver and Condoravdi (2007) hold that "[i]n Davidsonian Event Semantics the analysis of quantification is problematic: either quantifiers are treated externally to the event system and quantified in (cf. Landman, 2000), or else the definitions of the quantifiers must be greatly (and non-uniformly) complicated (cf. Krifka, 1989)". They suggest as an alternative a nonstandard framework in which verbal denotations hold of partial functions that map designated constants like "agent" and "theme" to individuals. For related criticism and similar proposals, see Eckardt (2010) and Winter and Zwarts (2011). I take Beaver and Condoravdi, 2007 as a representative example of these proposals (though there are important differences between them) and I discuss it in Section 4.

Contrary to such claims, I argue that the analysis of quantifier scope does not pose any special problems in an event semantic framework. That is, adopting one or the other view on quantifier scope does not entail a commitment on whether events are present in the system. For semanticists who reject quantifying-in as an option, such as Beaver & Condoravdi and Eckardt, it is possible to adopt a semantic approach to quantifier scope in a completely standard event-based framework. Conversely, adopting one or the other view on the presence of events does not force the semanticist to take a stance on whether quantifier scope is determined syntactically or semantically. Schematically, my strategy consists in filling a corner in the 2-by-2 matrix that is opened by the parameters mentioned above (see Table 1).

	No Events	Events
Syntactic account	e.g. May (1985)	e.g. Landman (2000)
Semantic account	e.g. Hendriks (1993)	*this paper*

Table 1: Analyses of quantification and events

This paper does not present in detail syntactic approaches to quantifier scope, since they can be extended to event semantic frameworks straightforwardly; see Landman (1996, 2000) for an overview. However, let me briefly mention why syntactic approaches have been considered problematic. In these approaches, type mismatches between verbs and quantificational arguments are resolved by movement. This is sometimes perceived as cumbersome. As Eckardt (2010) observes, "the semantic composition of even a simple sentence like *John likes most Fellini movies* requires quantifier raising, interpreted traces, coindexing, and lambda abstraction." Since syntactic approaches rely on covert movement, they entail the presence of a representational level (Logical Form) that is distinct from the surface level. As such, they are not directly compositional (Jacobson, 1999; Barker, 2002). Finally, there is an overgeneration worry: In languages and configurations where surface scope determines semantic scope (see e.g. Beghelli and Stowell (1997) for English, and S.-F. Huang (1981) and C.-T. J. Huang (1998) for Chinese), nothing short of additional assumptions ensures that raised quantifiers keep their relative order the same as before they raised.

Two caveats before we begin. First, the nonstandard systems in the papers cited above are motivated not only by the representation of quantificational arguments but also by additional considerations, such as the representation of stacked temporal modifiers as in *On most days, it rained in the afternoon* (Beaver and Condoravdi, 2007) and the ability to make all arguments of a verb semantically accessible at any point in the derivation (Eckardt, 2010). Second, I do not consider scopeless readings of quantifiers, such as cumulative quantification. When non-increasing quantifiers are involved, these readings increase the complexity of both event-based and eventless grammars because it is not possible to derive these readings by giving one quantifier scope over the other. My omission is justified because the claims by Beaver & Condoravdi and Eckardt about the difficulty of integrating quantifier scope and event semantics are not based on these complex cases. See Krifka (1999), Landman (2000) and Brasoveanu (2010) for discussion of relevant issues.

The rest of the paper is organized as follows. I first show in Section 2 that in the presence of type shifting rules, event semantics does not require a commitment to a representational level distinct from surface form as far as quantifiers are concerned. I then show in Section 3 that fixed-scope operators like negation and modals can be given a straightforward and standard treatment, and that in particular event semantics does not make it necessary to resort to a non-standard account of negation in terms of mereological fusion as claimed by Krifka (1989). Section 4 discusses the eventless system by Beaver and Condoravdi (2007) and shows that most aspects of that system can be reproduced in the present framework. Section 5 shows that coordination can be given a standard intersective denotation in the present framework, and critically reviews a claim to the effect that event semantics favors a collective account of coordination (Lasersohn, 1995). Section 6 concludes.

2 Quantification in a Neo-Davidsonian framework

The difference between syntactic and semantic approaches to quantifier scope is traditionally studied in classical Montagovian semantic systems, where verbs are translated as n-ary relations that hold between their arguments. Such a translation draws a firm semantic distinction between (obligatory) arguments and (optional) adjuncts. Expressions in which some arguments are missing, like *kiss Mary* or *John kissed*, are not assigned a truth value. Among alternatives that treat arguments and adjuncts on a par, the best-known one is the Neo-Davidsonian approach (Parsons, 1990). In a typical instantiation, verbs and all their projections up to the sentence level are translated as predicates of events, and verbal arguments modify events via thematic roles like agent and theme. Variations of this setup are found, for example, in Carlson (1984), Krifka (1989), Parsons (1995) and Landman (2000). At the sentence level, a silent operator (called *sentence mood operator* in

Krifka (1989) or more commonly *existential closure*) then binds the event argument, typically with an existential quantifier.

Some syntactic mechanism (e.g. the theta criterion) is assumed to make sure that the operator can only apply once all the syntactic arguments of the verb have been introduced to the derivation, and not earlier. For example, a sentence like *John kissed Mary* is translated as follows, disregarding tense:

(1) ⟦John kissed Mary⟧
$= \exists e.\mathbf{kiss}(e) \ \wedge \ \mathbf{ag}(e, \mathbf{john}) \ \wedge \ \mathbf{th}(e, \mathbf{mary})$

Such theories rely on syntactic devices, for example on the theta criterion, to label subjectless sentences like *kiss Mary* as ungrammatical; as far as the semantics is concerned, the system could assign such expressions a truth value, in this case, $\exists e.\mathbf{kiss}(e) \ \wedge \ \mathbf{th}(e, \mathbf{mary})$.

When a verbal argument is itself quantificational, it needs to take scope above this event quantifier. This is a standard assumption in Neo-Davidsonian theories. For example, the Scope Domain Principle in Landman (1996) states that only nonquantificational noun phrases can be "entered into scope domains". In the context of Landman's theory, where "scope domain" means "verbal denotation", this principle in effect says that only nonquantificational noun phrases can be interpreted in situ, and it has the consequence that all quantificational noun phrases must take scope over the event argument. For example, the correct translation of *John kissed every girl* according to the Scope Domain Principle is (2). This represents the fact that the sentence entails that for every girl, there is a separate event in which John kissed that girl. For example, the sentence *John kissed Mary* is represented as (3). It follows logically from (2) given the additional assumption that Mary is a girl (4).

(2) ⟦John kissed every girl⟧
$= \forall x[\mathbf{girl}(x) \rightarrow \exists e[\mathbf{kiss}(e) \ \wedge \ \mathbf{ag}(e, \mathbf{john}) \ \wedge \ \mathbf{th}(e, x)]]$

(3) ⟦John kissed Mary⟧
$= \exists e[\mathbf{kiss}(e) \ \wedge \ \mathbf{ag}(e, \mathbf{john}) \ \wedge \ \mathbf{th}(e, \mathbf{mary})]$

(4) ⟦Mary is a girl⟧
$= \mathbf{girl(mary)}$

The alternative translation in which the event quantifier takes wide scope, (5), expresses that there is a single event in which John kissed every girl. This contradicts not only the Scope Domain Principle and related assumptions, but also our intuitions about kissing, since we think of different kissings as different events. The following translation therefore does not seem to represent any reading of the sentence.

(5) $[\![$John kissed every girl$]\!]$
$= \exists e[\mathbf{kiss}(e) \ \wedge \ \mathbf{ag}(e, \mathbf{john}) \ \wedge \ \forall x[\mathbf{girl}(x) \rightarrow \mathbf{th}(e, x)]]$

In general, the event quantifier always takes lowest possible scope with respect to other scope taking elements. For example, sentence (6) only has the reading (7a) and cannot mean (7b). While (7b) might be ruled out for independent reasons (for example because almost every event will trivially make it true), the fact remains that the quantifier *no boy* must be able to take wide scope with respect to the event quantifier in order to derive the reading (7a). Even with respect to fixed scope operators like negation, the event quantifier always seems to take low scope (8).

(6) No boy laughed.

(7) a. $\neg\exists x[\mathbf{boy}(x) \ \wedge \ \exists e[\mathbf{laugh}(e) \ \wedge \ \mathbf{ag}(e) = x]]$ $\neg\exists x \gg \exists e$
“There is no laughing event that is done by a boy.”
b. $\exists e[\neg\exists x[\mathbf{boy}(x) \ \wedge \ \mathbf{laugh}(e) \ \wedge \ \mathbf{ag}(e) = x]]$ *$\exists e \gg \neg\exists x$
“There is an event that is not a laughing by a boy.”

(8) John didn’t laugh.

(9) a. $\neg\exists e[\mathbf{laugh}(e) \ \wedge \ \mathbf{ag}(e) = \mathbf{john}]$ $\neg \gg \exists e$
“There is no event in which John laughs.”
b. $\exists e\neg[\mathbf{laugh}(e) \ \wedge \ \mathbf{ag}(e) = \mathbf{john}]$ *$\exists e \gg \neg$
“There is an event in which John does not laugh.”

An additional reason for giving low scope to the event quantifier is more theory-internal: Many Neo-Davidsonian frameworks assume that thematic roles are functions (the Unique Role Requirement, Carlson, 1984; Parsons, 1990; Landman, 1996, 2000). This has the effect of making the wrong translation (5) a contradiction in all models in which there is more than one girl, since the Unique Role Requirement entails that no more than one girl can be the theme of a kissing event. The analysis to be developed here can accommodate the Unique Role Requirement. For clarity, I will represent thematic roles using functional notation from now on, e.g. “$\mathbf{th}(e) = x$” instead of “$\mathbf{th}(e, x)$”.

As described above, typical instantiations of the Neo-Davidsonian framework apply existential closure to the event quantifier at sentence level. Therefore, any theory of quantifier scope needs to give all argument quantifiers the ability to take scope above the sentence level to derive the correct truth conditions. It is here that a difference between syntactic and semantic theories of quantifier scope arises.

For syntactic theories such as May's Quantifier Raising (QR), it is no problem to raise a quantifier above sentence level; this is in fact their normal operating mode. This is illustrated in Figure 1. For convenience, I have followed Landman (1996, 2000) in placing the thematic roles directly into the verb meaning, but this is not crucial.

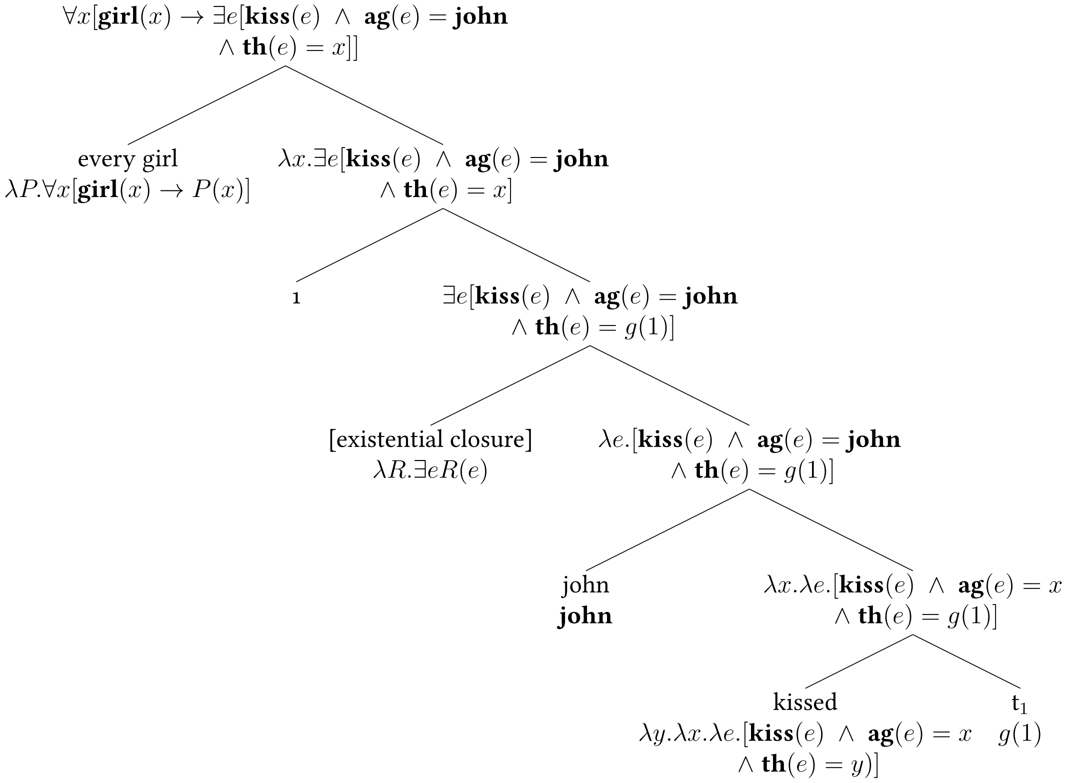

Figure 1: "John kissed every girl" in an event framework, using quantifier raising.

By contrast, many semantic theories are designed to allow quantifiers to be interpreted in situ. Some examples are the argument raising rule of Hendriks (1993), the type-shifting rule for quantifiers presented in the textbook by Heim and Kratzer (1998), and the continuation passing style transforms used in Barker (2002). Many such theories amount to lifting the type of the verb or verbal projection so that it expects a quantifier instead of an individual-type argument. In case a verb combines with multiple quantifiers, its type can be lifted several times. The order in which these lifting operations are applied to the verb determines the scope of its arguments. For example, in Hendriks' system, the order in which the argument raising rule is applied to a transitive verb determines the scope that its quantificational arguments take towards each other.

In the Neo-Davidsonian framework described above, the event quantifier is introduced by existential closure after any other quantifiers, but it always has to take scope under all of them. In a Hendriks-style system, this requires that every verb be type-lifted for the event quantifier that comes in the guise of existential closure. But since every sentence contains this event quantifier, one might then as well rewrite lexical entries of verbs to incorporate the existential closure over their event argument.

My formal proposal, then, is that verbs are not interpreted as predicates of events (10a), but as generalized existential quantifiers over events (10b). Conceptualizing Neo-Davidsonian event semantics this way requires a shift in thinking. Instead of denoting the set of all kissing events, think of "kiss" as being true of any set that contains a kissing event. I let the variable f range over event predicates.

(10) a. Previous Neo-Davidsonian approach: $[\![\text{kiss}]\!] = \lambda e[\mathbf{kiss}(e)]$
b. This approach: $[\![\text{kiss}]\!] = \lambda f \exists e[\mathbf{kiss}(e) \ \wedge \ f(e)]$

The entry in (10b) can be derived from the one in (10a) by the type-shifting principle A in Partee (1987), but this parallel should be taken with a grain of salt. Type shifting is generally understood to occur "online" during the computation of the meaning of a sentence, while the present proposal applies it "offline" in the lexicon. The move from (10a) to (10b) is better understood as an operation that rewrites an entire grammar, similarly to the continuization procedure in Barker (2002).

We will let not only verbs but all their projections hold of sets of events. Thus, we can think of a verb phrase like "kiss Mary" as being true of any set that contains a kissing event whose theme is Mary, and so on up the sentence.

(11) $[\![\text{kiss Mary}]\!] = \lambda f \exists e[\mathbf{kiss}(e) \ \wedge \ f(e) \ \wedge \ \mathbf{th}(e) = \mathbf{mary}]$

As an added bonus compared to syntactic approaches, putting existential closure into the lexical entry of the verb will automatically derive the fact that all other quantifiers always have to take scope above existential closure. This move is reminiscent of the way Carlson (1977) puts existential quantification over stages into the lexical semantics of stage-level predicates, thereby ensuring that bare plurals can denote kinds and their existential import takes narrowest scope.

Changing the type of verbs and verbal projections from sets of events to sets of sets of events gives us a handle on interpreting quantifiers in situ. On the old approach, a verb phrase had to be true of an event, so it was not clear what kind of event a verb phrase like “kiss every girl” could be true of. Now that verb phrases hold of sets of events, we can formulate the meaning of verb phrases containing quantifiers in an intuitive way: “kiss every girl” is true of any set of events that contains a potentially different kissing event for every girl.

(12) $[\![\text{kiss every girl}]\!]$
$= \lambda f \forall x[\textbf{girl}(x) \rightarrow \exists e[\textbf{kiss}(e) \ \wedge \ f(e) \ \wedge \ \textbf{th}(e) = x]]$

For simple declarative sentences, we still need a sentence-level operator, but it has a function somewhat different from existential closure: It asserts that the predicate is true of the set of all events. Intuitively, one might think of the world as the set of all events that exist. Then, the sentence-level operator asserts that the sentence is true of the world. As usual, I assume that syntax is responsible for making sure that the operator only applies once all the syntactic arguments of the verb have been introduced.

(13) $[\![[\text{closure}]]\!] = \lambda e.\textbf{true}$

This closure operator is similar to the downarrow operator of Dynamic Montague Grammar, which maps the dynamic interpretation of a sentence to a truth value (Groenendijk and Stokhof, 1990), and to the Lower operator of Barker and Shan (2008), which does the same for a continuized interpretation by applying it to a trivial continuation. All these type shifters are used to similar effect in their respective systems: They strip away the layers of complexity introduced by the semantic machinery and map a predicate to what are intuitively its truth conditions.

Back to the present proposal. I treat noun phrases as generalized quantifiers over individuals (type $\langle et, t\rangle$). This part of the analysis is completely standard. I use P for predicates of individuals (type $\langle et\rangle$):

(14) $[\![\text{every girl}]\!] = \lambda P \forall x[\textbf{girl}(x) \rightarrow P(x)]$

(15) $[\![\text{a diplomat}]\!] = \lambda P \exists x[\textbf{diplomat}(x) \ \wedge \ P(x)]$

Thematic roles can be introduced either as part of the verbal denotation or through other means. For concreteness, I assume that they are provided by separate syntactic heads that combine noun phrases with verbal projections and provide the necessary semantic type-lifting. In particular, a thematic role head like *theme* combines a quantificational noun phrase with the denotation of a verbal projection, which is a generalized quantifier over events, and returns another generalized quantifier over events. This ensures that all verbal projections have the same type, namely $\langle vt, t\rangle$, where v stands for the type of events. Here is the denotation of such a thematic role head (I use V for predicates of type $\langle vt, t\rangle$, and Q for predicates of type $\langle et, t\rangle$). Prepositions can follow exactly the same scheme:

(16) $[\![\text{[th]}]\!] = \lambda Q \lambda V \lambda f[Q(\lambda x[V(\lambda e[f(e) \ \wedge\ \mathbf{th}(e) = x])])]$

After this head combines with a quantificational noun phrase such as the one in (14), the resulting constituent is of type $\langle\langle vt, t\rangle, \langle vt, t\rangle\rangle$.

Under these assumptions, we can derive the meaning of a sentence like *John kissed every girl* in a variable-free manner, without the application of movement or traces, and with function application as the only operation. This is shown in Figure 2 for *John kissed every girl.* Compare this with Figure 1, where movement, trace interpretation, and lambda abstraction have been used for the same sentence.

The framework can be extended in different ways to derive quantifier scope ambiguities. For example, this could be done as in Hendriks (1993) by argument raising, or as in Beaver and Condoravdi (2007) by applying arguments to the verb in different orders. Another possibility is to lift the type of the thematic role heads, as shown in Figures 3 and 4. These figures show the surface and inverse scope readings of *A diplomat visited every country* respectively. The only difference between them is that the thematic role head [th] in the former has been replaced by [th-lift] in the latter. This results in inverse scope. We can capture the difference between languages in which surface order determines semantic scope and languages in which scopal order is free by adding or removing type-lifted thematic role heads like [th-lift] in Figure 4 from the lexicon. If one wants to generalize the system to the case where we have more than two quantifiers, and if one desires to avoid redundancy, one may want to formulate an operator that generates [th-lift] and other heads from [th] by a version of Hendriks' argument raising. This would have to be made available on a per-language basis, as opposed to being a theorem of the system.

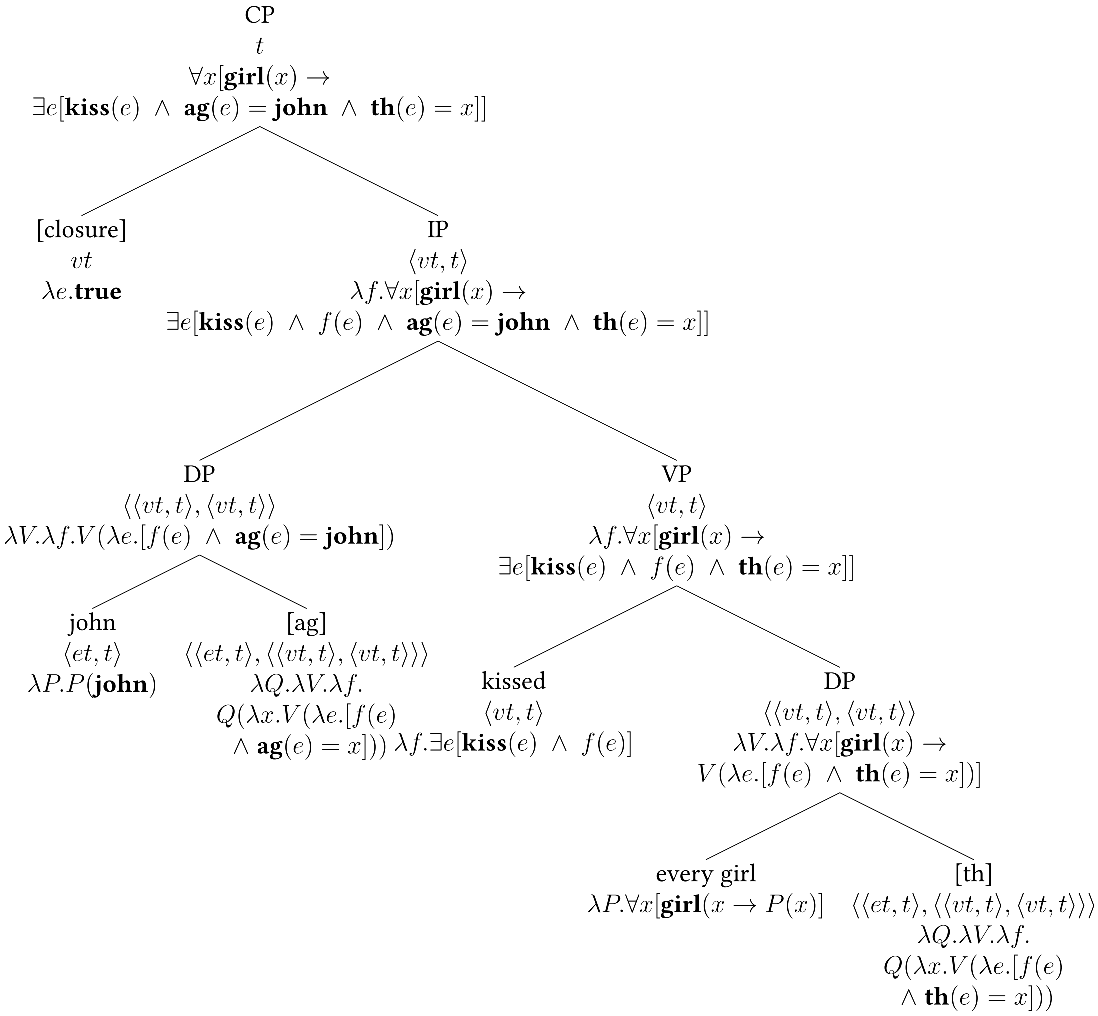

Figure 2: Basic illustration of the present framework, using the sentence “John kissed every girl.”

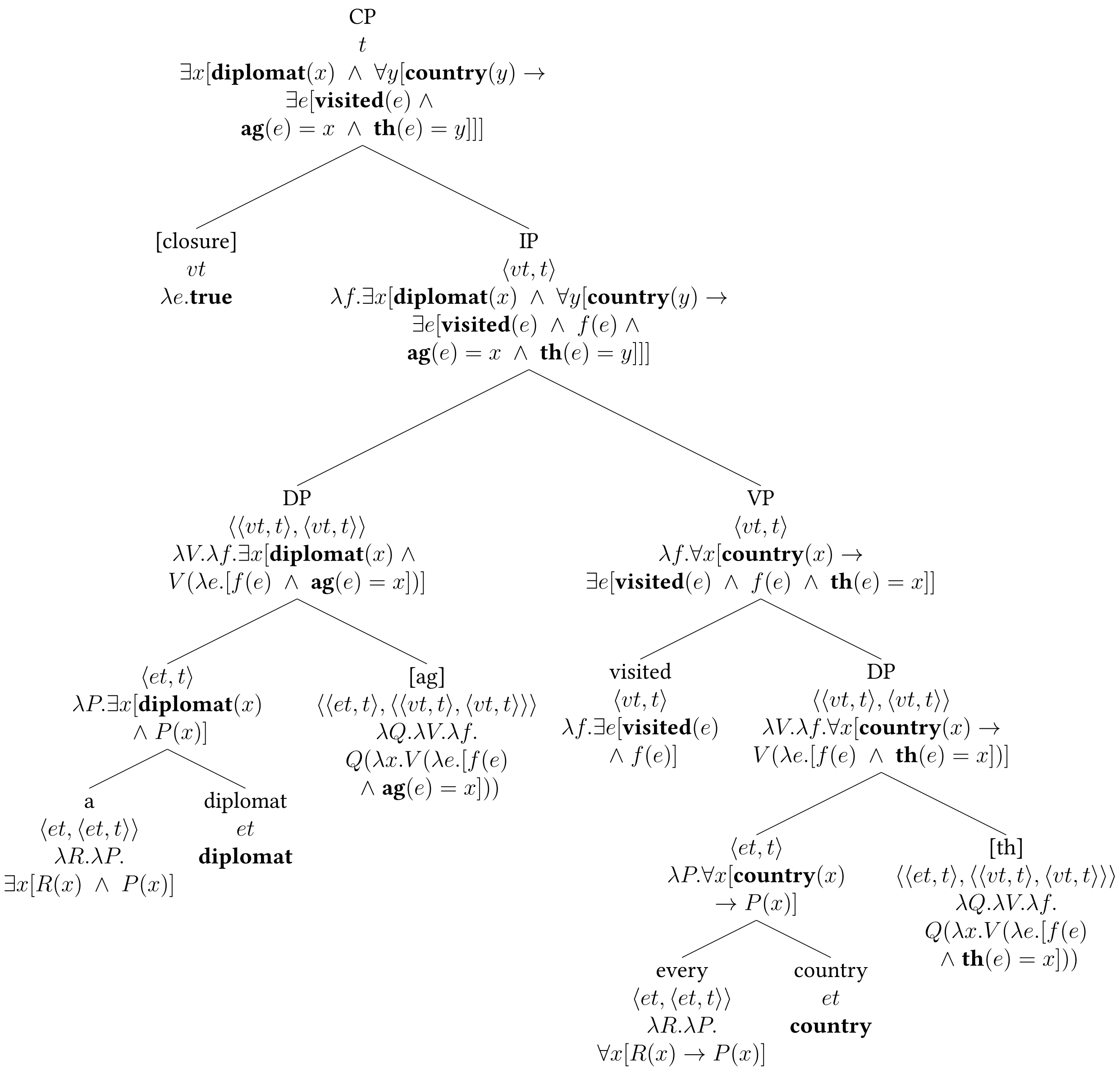

Figure 3: A diplomat visited every country (surface scope)

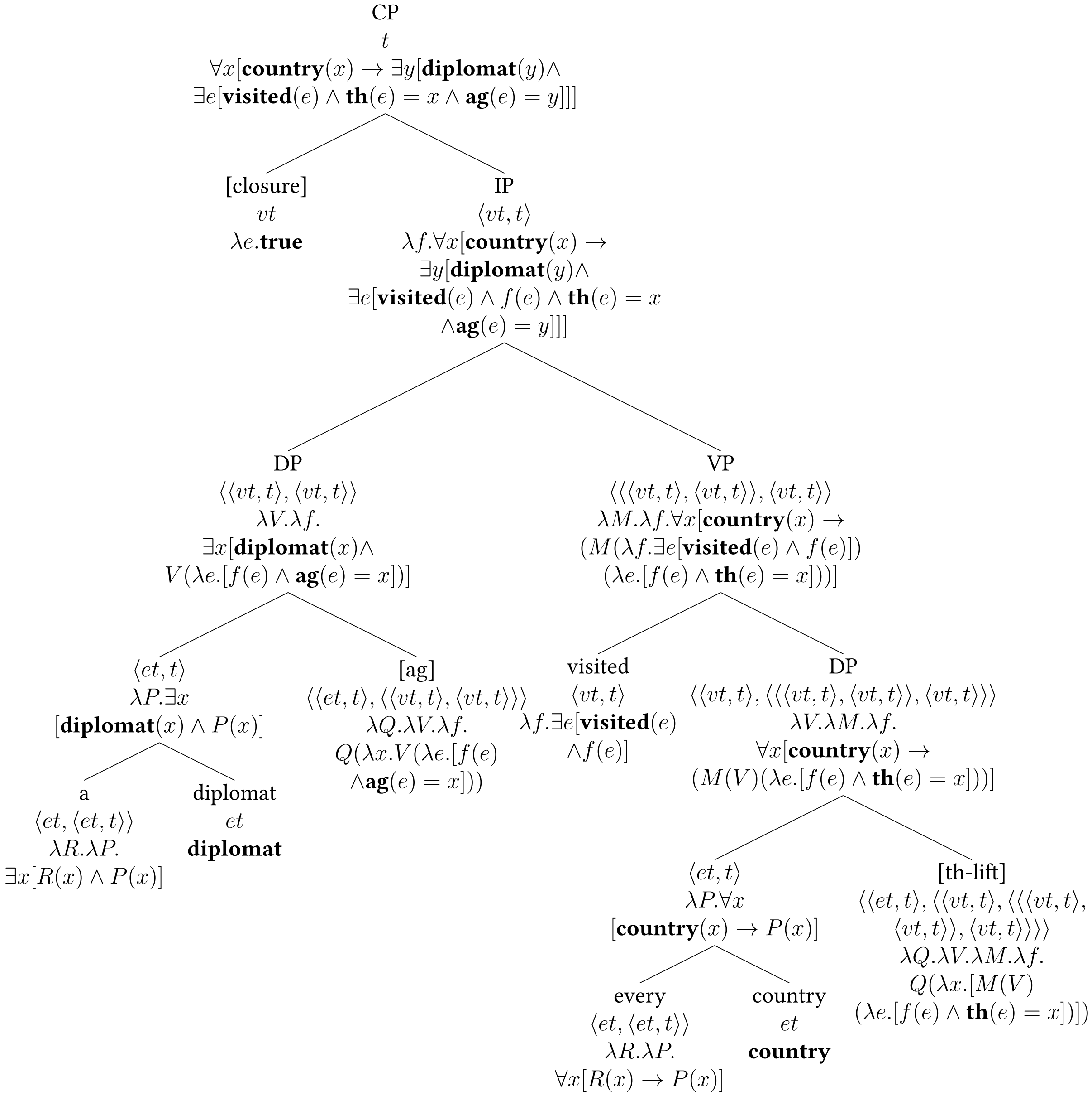

Figure 4: A diplomat visited every country (inverse scope)

3 Negation

In the system presented here, all verbal arguments and modifiers, no matter what their syntactic category is, uniformly have the same semantic type, namely $\langle\langle vt, t\rangle, \langle vt, t\rangle\rangle$. This applies in particular to scope-taking operators like negation and modals. In this section, I sketch an analysis of these operators, concentrating on negation. I compare the resulting treatment of negation to the fusion-based system in Krifka (1989).

Just like quantification, negation has been considered particularly difficult for event semantics because it leads to apparent scope paradoxes (Krifka, 1989). As observed by Smith (1975), *for*-adverbials like *for two hours* can take scope both above negation and below it. For example, (17) can be interpreted both as (17a) and as (17b):

(17) John didn't laugh for two hours.
  a. For two hours, it was not the case that John laughed.
  b. It was not the case that John laughed for two hours.

We have seen above, in connection with examples like (6) and (8), that negation always seems to take scope above the event quantifier. This would mean that in order to lead to interpretations like (17a), the *for*-adverbial must be able to take scope above the event quantifier. If one assumes, as Krifka does, that the event quantifier is introduced at the sentential level via existential closure, this means that the *for*-adverbial must be able to take scope at the sentential level. Krifka considers this conclusion undesirable. Let us adopt this point of view as well here and require of our framework that we must be able to interpret *for*-adverbials at VP-level. One certainly does not want to be forced by the choice of one's framework to take a position on the scope of *for*-adverbials, as there is currently no consensus on whether they attach below or above the subject. This issue is relevant in connection with the interaction of *for*-adverbials and the Perfect. See Rathert (2004) for a discussion of the relevant issues and literature.

Krifka himself resolves the apparent scope paradox by concluding that negation, after all, takes scope under and not over the event quantifier, contrary to what is suggested by the facts in (6) and (8). Given the background assumption that *for*-adverbials do not take scope at the sentential level, this decision is necessary for Krifka in order to explain why *for*-adverbials take scope both above and below negation. But this decision requires translating negation in a nonstandard way. Krifka uses the mereological concept of fusion for this purpose. Simply put, the fusion of an event predicate is something which has the type of an event and which is obtained by merging all the events that satisfy the event predicate. Krifka translates *did not* as involving the fusion of all the events that take place within some time interval. Parthood is shown as $\leq$ here:

(18) $[\![\text{did not}]\!]_{\textit{Krifka}}$
$= \lambda P \lambda e \exists t[e = \textsc{Fusion}(\lambda e'[\tau(e') \leq t]) \wedge \neg\exists e''[P(e'') \wedge e'' \leq e]]$

Based on this entry, Krifka translates a sentential event predicate like *John didn't laugh* as a predicate that is true of any fusion of events that all take place within some time, so long as none of them is an event of John's laughing:

(19) $[\![\text{John did not laugh}]\!] =$
$\exists e \exists t[e = \textsc{Fusion}(\lambda e'[\tau(e') \leq t])$
$\wedge \neg\exists e''[e'' \leq e \wedge \mathbf{laugh}(e'') \wedge \mathbf{ag}(e'') = \mathbf{john}]]$

This translation is very weak. It amounts to saying "There is a time during which John did not laugh", without placing any constraints on when this time should be. So Krifka introduces further modifications inspired by the anaphoric treatment of tense in the style of Partee (1973). The net effect of these modifications is that the existentially quantified time variable t is restricted to be a part of the reference time introduced by the past morpheme.

Krifka's fusion-based negation system of has been both influential and controversially debated in the literature. For example, it plays an important role in the account of scopal effects of *for*-adverbials in Zucchi and White (2001) and in the formal reconstruction of various analyses of the meaning of *until* in de Swart (1996) and Condoravdi (2002). One of the main questions in these discussions regards the ontological status of fusions. Some authors (de Swart, 1996; de Swart and Molendijk, 1999) embrace these fusions and even take them as support for the claim that "negation is a stativizer", that is, negation yields predicates of states. However, this claim is controversial (Giannakidou, 2002; Condoravdi, 2002; Csirmaz, 2006). In the absence of a consensus on the status of negation-based fusions, it is worth revisiting the evidence that led to their introduction in the first place.

In the present system, we do not need to resort to mereological fusion, because one of the premises of the argument that leads to Krifka's scope dilemma is missing from our system. Since our event quantifier takes scope at the lowest possible level, the scopal interaction between *for*-adverbials and negation does not force us to conclude that negation takes scope under the event quantifier. This is so even if we also maintain, as Krifka does, that the *for*-adverbial never takes scope at the sentential level. As a result, we can formulate the meaning of *not* in terms of logical negation, without fusions.

(20) $[\![\text{not}]\!] = \lambda V \lambda f \neg V(\lambda e[f(e)])$

I treat *did* as semantically vacuous. Its presence only morphologically signals the presence of past tense. This idea is common in semantic treatments of tense; see for example von Stechow (2009), Section 6, for details and references.

Sentence (19) receives the LF in (21a), which results in a straightforward translation that does not involve reference to fusions (21b):

(21) a. $[_{\text{CP}}$ [closure] $[[_{\text{DP}}$ john [ag]] $[_{\text{VP}}$ did not laugh]]]
b. $\neg\exists e[\mathbf{laugh}(e) \wedge \mathbf{ag}(e) = \mathbf{john}]$

This translation ignores tense. Let us now add an anaphoric treatment of tense to restrict the translation to the reference time (written $t_{\mathbf{r}}$), again following Partee (1973). Since Krifka assumes such a treatment too, this move does not change the relative complexities of the two systems under comparison. Here and below, I write temporal inclusion (which may or may not be conceptualized as mereological parthood) as $\subseteq$ and temporal precedence as $\ll$. The following closure operator represents the meaning of the past tense:

(22) $[\![\text{[past-closure]}]\!]$
$= \lambda V[t_{\mathbf{r}} \ll \mathbf{now} \ \wedge \ V(\lambda e[\tau(e) \subseteq t_{\mathbf{r}}])]$

In this entry, the subformula $t_{\mathbf{r}} \ll \mathbf{now}$ is not in the scope of V. This, together with the fact that nothing ever takes scope above the closure operator, ensures that it is always interpreted with wide scope.

On the assumption that negation and *for*-adverbials can combine with the verb phrase in any order, the following translation of a *for*-adverbial generates the desired readings for (17).

(23) $[\![\text{for two hours}]\!]$
$= \lambda V \lambda f \exists t[\mathbf{hours}(t) = 2 \wedge t \subseteq t_{\mathbf{r}}$
$\wedge \forall t'[t' \subseteq t \rightarrow V(\lambda e[f(e) \wedge \tau(e) = t'])]]$

My analyses of (17a) and (17b) are shown in (24) and (25) respectively. The full derivations are shown in Figures 5 and 6. In both LFs, the *for*-adverbial takes scope at VP level. Thus, we avoid resorting to the assumption that Krifka viewed as problematic, namely that the *for*-adverbial is able to take scope at sentential level. The occurrence of $t_{\mathbf{r}}$ in (23) is crucial; it prevents (24) from being trivially verified by any two-hour interval outside of the reference time.

(24) a. For two hours, it was not the case that John laughed.
b. $[_{\text{CP}}\ [[_{\text{DP}}$ john [ag]] $[_{\text{VP}}\ [_{\text{VP}}$ did not laugh] $[_{\text{PP}}$ for 2 hours]]]]
c. $t_{\mathbf{r}} \ll \mathbf{now} \wedge \exists t[\mathbf{hours}(t) = 2 \wedge t \subseteq t_{\mathbf{r}} \wedge \forall t'[t' \subseteq t \rightarrow$
$\neg\exists e[\mathbf{laugh}(e) \wedge \mathbf{ag}(e) = \mathbf{john} \wedge \tau(e) = t' \subseteq t_{\mathbf{r}}]]]$

(25) a. It was not the case that John laughed for two hours.
b. $[_{\text{CP}}\ [[_{\text{DP}}$ john [ag]] $[_{\text{VP}}$ did not $[_{\text{VP}}$ laugh $[_{\text{PP}}$ for 2 hours]]]]]
c. $t_{\mathbf{r}} \ll \mathbf{now} \wedge \neg\exists t[\mathbf{hours}(t) = 2 \wedge t \subseteq t_{\mathbf{r}} \wedge \forall t'[t' \subseteq t \rightarrow$
$\exists e[\mathbf{laugh}(e) \wedge \mathbf{ag}(e) = \mathbf{john} \wedge \tau(e) = t' \subseteq t_{\mathbf{r}}]]]$

In (23), I have followed Dowty (1979) and others in treating the *for*-adverbial as quantifying over subintervals of a two-hour-long interval, rather than quantifying on subevents of an event whose runtime is two hours, as in Krifka (1998) for example. Otherwise, in (17a) we would need to resort to something like Krifka's fusion after all, because in order for there to be a suitable two-hour event we would need to introduce a "negative event" whose runtime would be the two hours in which John didn't laugh. For independent justification of the subinterval-based translation of the *for*-adverbial used here, and for an alternative account of its scopal behavior, see Champollion (2010), Chapters 6 and 9.

Finally, let me briefly note that modals and other fixed-scope operators can be treated in the same way as negation. Setting aside the well-known intricacies of possible-world semantics, the lexical entry for modals like *may* and *must* will look like this:

(26) $[\![\text{may}]\!] = \lambda V \lambda f \Diamond V(\lambda e[f(e)])$

(27) $[\![\text{must}]\!] = \lambda V \lambda f \Box V(\lambda e[f(e)])$

For these entries to lead to interpretable formulas, the interpretation of the representation language must of course be suitably intensionalized. The details do not interact with my proposal.

4 Previous work: Beaver and Condoravdi (2007)

This section provides a comparison of the present system with "linking semantics", the system presented by Beaver and Condoravdi (2007, here B&C). This system is

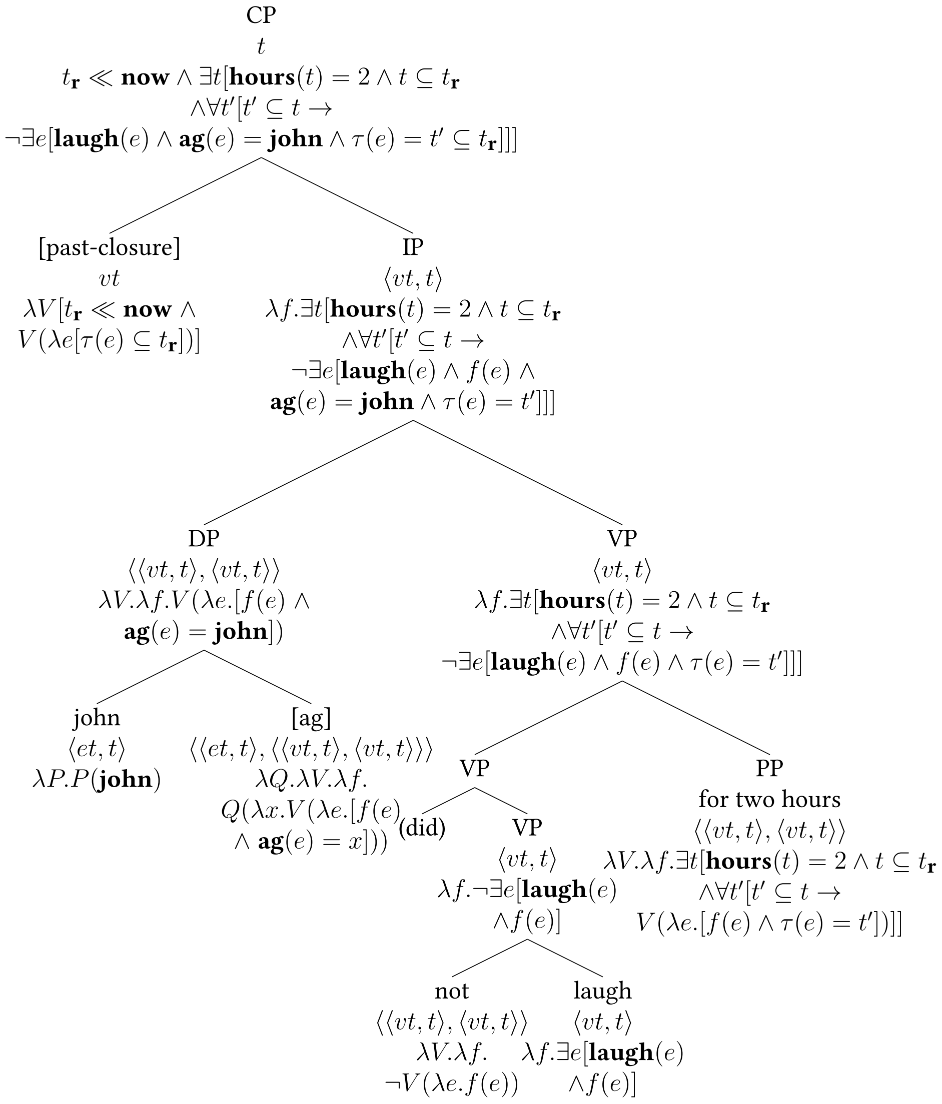

Figure 5: LF for Example (24): John [didn't laugh] for two hours

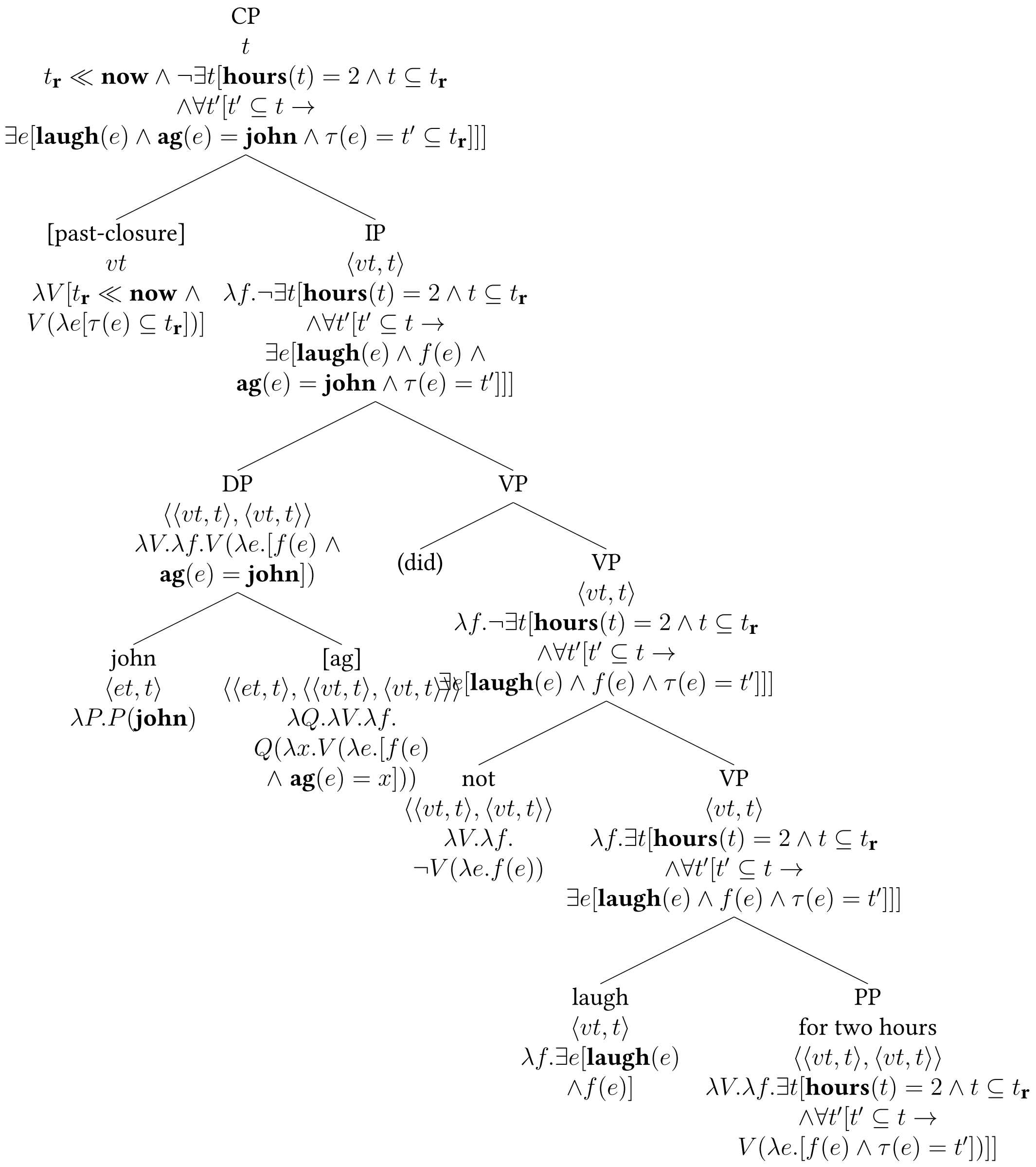

Figure 6: LF for Example (25): John didn't [laugh for two hours]

taken here as a representative example of previous work on the interaction of compositional semantics and event semantics. Its authors present it as surpassing both (Neo-)Montagovian semantics and Davidsonian event semantics. Like the present one, B&C's system is designed to provide a clean and compositional account of the interaction of events and quantifiers. But the system adopts a nonstandard view of the semantics of action sentences that does not use events, and this leads to problems. The main point of this section is that we can have our cake and eat it too: we can reconcile B&C with Davidsonian event semantics and keep the strengths of both systems.

The main idea in B&C is that verbs and verbal projections denote sets of "role assignments", that is, partial functions that map labels like ARG1, ARG2 and T (intuitively, agent, theme, and time) to appropriate values. So in a model where John kicked Bill at 1pm, the sets denoted by *kick*, by *kick Bill* and by *John kick Bill* each contain at least the role assignment $g_1 = [\textsc{arg1}, j;\ \textsc{arg2}, b;\ \textsc{t}, 1pm]$. Among the strengths of B&C's system are a clean and compositional account of the interaction of events and quantifiers, and an account of stacked temporal modification. The system in B&C derives all the results described so far. In particular, their treatment of quantification, which they see as their main advantage over event semantics, is very similar to mine. However, their move away from event semantics is not free of drawbacks.

The first problem concerns argument reduction. In event semantics, verbal modifiers like *at noon* and *in the bathroom* are interpreted conjunctively, so that entailments like (28a) are modeled as logical entailments (28b) (Carlson, 1984; Parsons, 1990). This treatment of verbal modification is considered a very powerful argument in favor of event semantics (Landman, 2000, ch. 1). In B&C's system, the corresponding entailment in (28c) is non-logical and needs to be stipulated for each verb V via an "argument reduction" principle that says that if V holds of a role assignment, V also holds of any restriction of the same assignment. Thus, a major motivation for Davidsonian event semantics as a logic of verbal modification fails to carry over to B&C's account.

(28) a. Jones buttered the toast at noon. ⇒ Jones buttered the toast.
b. $[\exists e.\mathbf{butter}(e) \wedge \mathbf{ag}(e) = j \wedge \mathbf{th}(e) = \mathbf{toast} \wedge \tau(e) = \mathbf{noon}]$
$\Rightarrow [\exists e.\mathbf{butter}(e) \wedge \mathbf{ag}(e) = j \wedge \mathbf{th}(e) = \mathbf{toast}]$
c. $\mathbf{butter}([\textsc{arg1}, j;\ \textsc{arg2}, \mathbf{toast};\ \mathbf{toast}, \mathbf{noon}])$
$\Rightarrow \mathbf{butter}([\textsc{arg1}, j;\ \textsc{arg2}, \mathbf{toast}])$

The second problem concerns the treatment of time in B&C. They represent the surface scope reading of a sentence like (29a) as in (29b). This would be too strong because it requires all the visits to happen simultaneously at time t. To avoid this, B&C stipulate a "temporal closure" principle: if a verb applies to a role assignment which maps $\textsc{t}$ to a given interval t, then for each of its superintervals t', the verb also applies to an otherwise equal role assignment that maps T to t'. This hard-wired approach to temporal closure overgenerates. For example, the invalid argument in (30a) is wrongly predicted valid since temporal closure causes (30b) to entail (30c).

(29) a. A diplomat visited every country.
b. $\exists t.t < \textbf{now} \wedge \exists x.\textbf{diplomat}(x) \wedge$
$\forall y.\textbf{country}(y) \rightarrow \textbf{visit}([\textsc{arg1}, x; \textsc{arg2}, y; \textsc{t}, t])$

(30) a. It took John five years to learn Russian.
$\not\Rightarrow$ It took John ten years to learn Russian.
b. $\exists t.t < \textbf{now} \wedge \textbf{years}(t) = 5 \wedge \textbf{learn}([\textsc{arg1}, j; \textsc{arg2}, r; \textsc{t}, t])$
c. $\exists t.t < \textbf{now} \wedge \textbf{years}(t) = 10 \wedge \textbf{learn}([\textsc{arg1}, j; \textsc{arg2}, r; \textsc{t}, t])$

The present system avoids the need for stipulating argument reduction and temporal closure principles. Note that B&C's role assignments are very similar to properties of events. For example, g_1 above corresponds to the property of being an event whose agent is John, whose theme is Bill, and which takes place at 1pm. Note that this property could in principle apply to more than one event, for example if John kicked and slapped Bill at the same time. So in terms of event semantics, a role assignment corresponds to a set of events and not just to one event. Since B&C's verbal projections denote sets of role assignments, we need to use an event semantics in which verbal projections denote sets of sets of events. The present system fits the bill and its derivations are quite similar to the ones in B&C. (This is no accident, because the present system originally arose from the attempt to reconstruct B&C in an event-semantic framework.) For comparison, I show a B&C-style derivation in (31) and its counterpart in (32). Here, r, r' ranges over role assignments, f over sets of events, L over sets of role assignments, and V over sets of sets of events. Simplifying a bit, $r + [\textsc{arg1}, m]$ can be read as the result of extending f by a new entry that maps $\textsc{arg1}$ to m.

(31) a. ⟦Mary⟧ = $\lambda P.P(m)$
b. ⟦Mary:$\textsc{arg1}$⟧ = $\lambda L \lambda r.L(r + [\textsc{arg1}, m])$]
c. ⟦[past]⟧ = $\lambda L \lambda r.L(r) \wedge r(\textsc{t}) < \textbf{now}$
d. ⟦laugh [past]⟧ = $\lambda r'.\textbf{laugh}(r') \wedge r'(\textsc{t}) < \textbf{now}$

e. $[\![$Mary:$\textsc{arg1}$ laugh [past]$]\!]$ = $\lambda r.\mathbf{laugh}(r + [\textsc{arg1}, m]) \wedge r(\textsc{t}) < \mathbf{now}$

f. Mary laughed iff $\exists t[\mathbf{laugh}([\textsc{t}, t; \textsc{arg1}, m]) \wedge t < \mathbf{now}]$

(32) a. $[\![$Mary$]\!]$ = $\lambda P.P(m)$

b. $[\![$[ag] Mary$]\!]$ = $\lambda V \lambda f.V(\lambda e.[f(e) \wedge \mathbf{ag}(e) = m])]$

c. $[\![$[past]$]\!]$ = $\lambda V \lambda f \exists t[t < \mathbf{now} \wedge V(\lambda e[f(e) \wedge \tau(e) \subseteq t])]$

d. $[\![$[closure]$]\!]$ = $\lambda V.V(\lambda e.\top)$

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

f. $[\![$[closure][past][ag] Mary laugh$]\!]$ = $\exists t[t < \mathbf{now} \wedge \exists e[\mathbf{laugh}(e) \wedge \mathbf{ag}(e) = m \wedge \tau(e) \subseteq t]]$

In (32), I have deviated from B&C in distinguishing between the runtime of the event, $\tau(e)$, and the reference time interval of the sentence, t. The tense morpheme (32c) relates the two by temporal inclusion, written as $\subseteq$. This removes the need for B&C's temporal closure principle. The tensed version of (29a) comes out as in (33); the underlined bit requires that each visit is contained within the reference interval, but does not require all visits to take place at the same time. For consistency with B&C, I also give the tense quantifier widest scope, though this is not crucial.

(33) $\exists t.t < \mathbf{now} \wedge \exists x.\mathbf{diplomat}(x) \wedge \forall y.\mathbf{country}(y) \rightarrow \exists e.\mathbf{visit}(e) \wedge \mathbf{ag}(e) = x \wedge \mathbf{th}(e) = x \wedge \underline{\tau(e) \subseteq t}$

Unlike B&C, there is no overgeneration problem. I translate the matrix clauses of (30a) as in (34). The embedded clause is tenseless (or has present tense) instead of past tense, and therefore does not contribute $\subseteq$. The underlined parts of (35a) and (35b) block the inference in (30a).

(34) $[\![$It took John n years to$]\!]$ = $\lambda V \exists t.t < \mathbf{now} \wedge \mathbf{years}(t) = n \wedge V(\lambda e.\mathbf{ag}(e) = j \wedge \tau(e) = t)$

(35) a. $\exists t.t < \mathbf{now} \wedge \mathbf{years}(t) = 5 \wedge \exists e[\mathbf{learn}(e) \wedge \mathbf{ag}(e) = j \wedge \mathbf{th}(e) = r \wedge \underline{\tau(e) = t}]$

b. $\exists t.t < \mathbf{now} \wedge \mathbf{years}(t) = 10 \wedge \exists e[\mathbf{learn}(e) \wedge \mathbf{ag}(e) = j \wedge \mathbf{th}(e) = r \wedge \underline{\tau(e) = t}]$

There is one point in which B&C does afford additional formal expressivity compared to the present system. In their treatment of (36a), they model the dependency between the two temporal modifiers by letting the one of them write its denotation into the value of $\textsc{t}$, and letting the other one read it out and then replace it with its own value. There is no way to reproduce this behavior one-to-one, as we cannot compositionally map a set of events to another one in a way that would simulate overwriting runtimes. In any case, B&C's system is not general enough: it can only handle temporal anaphora between two temporal modifiers of the same "event" or role assignment. A full treatment of this kind of temporal anaphora needs to be able to cross sentence boundaries (Champollion, 2012).

(36) a. Last year, I visited Bill in July.
b. Last year, I lived in Rome. I visited Bill in July.

To sum up this section, verbal modification remains a strong motivation for Davidsonian event semantics.

5 Conjunction

This section discusses the interaction of the present system with conjunctive coordination of verbs and verb phrases, focusing on the word *and*. This can be used both intersectively, as in *John lies and cheats*, and collectively, as in *John and Mary met*. This suggests that *and* is ambiguous between an intersective and a collective interpretation. Winter (2001) argues convincingly against the ambiguity assumption. This suggests one of two theories: on the collective or "non-boolean" theory, all occurrences of *and* are collective; on the intersective or "boolean" theory, all occurrences are intersective. The collective theory is pursued, in various guises and to various degrees, in Lasersohn (1995) and Heycock and Zamparelli (2005). For discussion and criticism of the collective theory and arguments for the intersective theory, see Champollion (2013, 2014). In this section I show that the present framework easily supports the intersective theory. I compare and contrast the present framework with Lasersohn (1995, ch. 14). There are other implementations of coordination in event semantics besides Lasersohn's and the present one. For a type-logical implementation, see for example Forbes, 2012. Here I focus on Lasersohn's argument that the interaction of event semantics with the meaning of the adverb *alternately* provides an argument for the collective theory. I refute this argument below. The upshot of this section will be that an intersective theory of coordination is at least equally viable in an event semantic framework. Thus, adopting event semantics does not commit us to choosing one theory of coordination over another.

Lasersohn makes the typical assumption (the one I have rejected in Section 2) that sentence radicals like *John sang* are interpreted as event predicates. He models sentence-level *and* as a collective formation operator that acts on such sentence radicals, on a par with group-forming noun phrase conjunction. For example, "the sentence *John sang and Mary danced* can be interpreted as a predicate which truthfully applies to a group of events, one member of which is an event of John singing, and another member of which is an event of Mary dancing." (Lasersohn, 1995, p. 268)

Lasersohn models collective events as sets. This is mainly motivated by his treatment of *alternately*, which I discuss at the end of this section (see also Winter (1995) for some critical remarks). He generalizes his entry for non-boolean *and* from the propositional case to arbitrary conjoinable types. (A conjoinable type is a type that "ends in t", that is, it is either t or a type of the shape $\alpha\beta$ where α is any type whatsoever and β is a conjoinable type.) In the special case of one-place predicates, this gives the following result:

(37) a. $[\![\text{and}]\!]_{Lasersohn} = \lambda P_1.\lambda P_2.\lambda e.\exists e_1 \exists e_2.P_1(e_1) \wedge P_2(e_2) \wedge e = \{e_1, e_2\}$
b. $[\![\text{sing and dance}]\!]_{Lasersohn} = \lambda e.\exists e_1 \exists e_2.\textbf{sing}(e_1) \wedge \textbf{dance}(e_2) \wedge e = \{e_1, e_2\}$

Generalized intersective *and* amounts to intersection both in the case of predicate conjunction and in the case of quantifier conjunction. This can be seen from the application of the following recursive rule (e.g. Partee and Rooth, 1983). Let τ range over conjoinable types, and let σ_1 and σ_2 range over any type. Then define generalized intersection as follows and identify the meaning of *and* with it:

(38)
$$\sqcap_{\langle \tau, \tau\tau \rangle} =_{def} \begin{cases} \wedge_{\langle t, tt \rangle} & \text{if } \tau = t \\ \lambda X_\tau \lambda Y_\tau \lambda Z_{\sigma_1}.X(Z) \sqcap_{\langle \sigma_2, \sigma_2\sigma_2 \rangle} Y(Z) & \text{if } \tau = \langle \sigma_1, \sigma_2 \rangle \end{cases}$$

Roughly, this says that a conjunction of sentences S_1 *and* S_2 is true whenever both of the conjuncts are true, and a conjunction of subsentential constituents C_1 *and* C_2 denotes their intersection. The application of this rule to event predicates and event quantifiers is as follows:

(39) **Conjunction of event predicates:**
$[\lambda e.F_{vt}(e)] \sqcap_{\langle vt, \langle vt, vt \rangle \rangle} [\lambda e.G_{vt}(e)]$
$= [\lambda e.F_{vt}(e) \wedge G_{vt}(e)]$

(40) **Conjunction of event quantifiers (this system):**
$[\lambda f.\exists e.F_{vt}(e) \wedge f(e)] \sqcap_{\langle \langle vt, t \rangle, \langle \langle vt, t \rangle, \langle vt, t \rangle \rangle \rangle} [\lambda f.\exists e.G_{vt}(e) \wedge f(e)]$
$= [\lambda f.[\exists e.F_{vt}(e) \wedge f(e)] \wedge [\exists e'.G_{vt}(e') \wedge f(e')]]$

The important thing to notice about these two applications is that in (39), there is no event quantifier, while in (40), there are two. So the assumption that verbal projections are interpreted as event predicates, as in (39) is not readily compatible with the intersective theory of *and* because it forces both verbal predicates to apply to the same event. Take Davidson's example of a ball that it at once rotating quickly and heating up slowly (Davidson, 1969). This example is generally taken to show that there must be two events involved, since one and the same event cannot be both quick and slow. If the conjoined verb phrases in the sentence (41) are interpreted as event predicates, as in (42a), they cannot be interpreted intersectively. (I assume that intersective adverbs have entries as in (43).) By contrast, if the conjoined verb phrases are interpreted as event quantifiers, as on the present proposal, the intersective interpretation is unproblematic. This is because rule (38) ends up causing logical conjunction to have wide scope over the event quantifiers (42b).

(41) The ball rotated quickly and heated up slowly.

(42) ⟦rotate quickly⟧ $\sqcap$ ⟦heat up slowly⟧ =

a. $\lambda e.\textbf{rotate}(e) \land \textbf{quickly}(e) \land \textbf{heat-up}(e) \land \textbf{slowly}(e)$

b. $\lambda f.[\exists e.\textbf{rotate}(e) \land \textbf{quickly}(e) \land f(e)]$
$\land[\exists e'.\textbf{heat-up}(e') \land \textbf{slowly}(e') \land f(e')]$

(43) ⟦quickly⟧ = $\lambda V.\lambda f.V(\lambda e.\textbf{quickly}(e) \land f(e))$

When the verb phrase denotation (42b) is combined with the denotation of the subject in the same way as is illustrated in Figure 2, the result predicts that sentence (41) is true just in case there is an event e in which the ball rotated quickly and there is an event e' in which it heated up slowly. If desired, one can furthermore apply the treatment of tense presented in Section 3 in order to narrow down the reference time interval in which sentence (41) situates the two events. When the length of that interval is zero, the two events are required to be simultaneous.

The treatment of verbs as involving event quantifiers also provides us with a way to treat the scopal interaction of conjunction and indefinites. Sentence (44) is usually discussed with respect to the relative scope of the conjunction and the indefinite (Rooth and Partee, 1982; Partee and Rooth, 1983).

(44) John caught and ate a fish.

Rooth and Partee (1982) claim that this sentence only has a "one fish" reading (where the existential takes scope over the indefinite, i.e. John ate the fish he caught), and lacks a "two fish" reading (i.e. John caught a fish and ate a fish). They note that the "one fish" reading is generated by the Gazdar conjunction rule if transitive verbs are assumed to have type $\langle e, et\rangle$, rather than $\langle\langle et, t\rangle, et\rangle$ as in Montague (1973). Hendriks (1993) disagrees with their judgment and argues that the "two fish" reading is dispreferred for pragmatic reasons (because it can also be expressed in a less ambiguous way as *John caught a fish and ate a fish*) but that it is available with the right continuation:

(45) John caught and ate a fish. The fish he caught was inedible, and the fish he ate caught his eye.

Judgments on this kind of sentence vary. Bittner (1994) claims that (46a) "intuitively requires that there be some car that John bought and sold", while Winter (1995) claims, following Hendriks, 1993, p. 52 that the "prominent reading" of the similar sentence (46b) is the one that can be paraphrased as "John sold a car and bought a car".

(46) a. John bought and sold a car.
b. John sold and bought a car.

Once we move into event semantics, a new issue besides the scope of the indefinite arises: what are the thematic roles assigned by the various verbs involved? In (44), does the catching event stand in the same relation (say, *theme*) vis-à-vis the fish that was caught as the eating event does vis-à-vis the fish that was eaten, or are there two different relations (I'll call them *prey* and *food*)? And does John stand in the same relation (say *agent*) to both events, or is he the *catcher* of one event and the *eater* of the other?

To some extent, this question is resolved as a theory-internal matter. For general discussion, see Dowty (1991). On the traditional view of thematic roles, represented e.g. in Gruber (1965) and Jackendoff (1972), thematic roles encapsulate generalizations over shared entailments of argument positions in different predicates. Thus, in the fish scenario it is possible for John to stand in the same relation (*agent*) to both the catching event and the eating event, since in each case there is a sense in which John initiates the event, is responsible for it, etc. An alternative view sees thematic roles as verb-specific relations (Marantz, 1984): John stands in two different relations (*catcher* and *eater*) to the two events, and the same holds for the fish (*prey* and *food*). Coordination of verbal predicates may (and on the alternative view, must) involve different thematic roles. Unergative verbs, whose subjects are agents, can be coordinated with unaccusative verbs, whose subjects are non-agents, as the following example shows:

(47) John walked and fell.

Here, I illustrate that the present framework can accommodate coordination of various kinds. Let us start with the simplest case: assume that there are only two thematic roles at play, *agent* and *theme*. I will withdraw this assumption below. On this view, the "one-fish" reading of (44) is represented as follows.

(48) $[\exists x.\mathbf{fish}(x) \wedge [\exists e.\mathbf{catch}(e) \wedge \mathbf{ag}(e) = j \wedge \mathbf{th}(e) = x] \wedge [\exists e'.\mathbf{eat}(e') \wedge \mathbf{ag}(e') = j \wedge \mathbf{th}(e') = x]]$

Here is how the verb phrase of this reading is derived.

(49) a. $\llbracket[\text{ catch and eat }]\rrbracket = \lambda f.[\exists e.\mathbf{catch}(e) \wedge f(e)] \wedge [\exists e'.\mathbf{eat}(e') \wedge f(e')]$
b. $\llbracket[\text{th}]\rrbracket = \lambda Q \lambda V \lambda f[Q(\lambda x[V(\lambda e[f(e) \ \wedge \ \mathbf{th}(e) = x])])]$ = (16)
c. $\llbracket[\text{a fish}]\rrbracket = \lambda P \exists x.\mathbf{fish}(x) \wedge P(x)$
d. $\llbracket[\text{th}]([\text{a fish}])\rrbracket = \lambda V \lambda f[\exists x[\mathbf{fish}(x) \wedge [V(\lambda e[f(e) \ \wedge \ \mathbf{th}(e) = x])]]]$
e. $\llbracket[\text{th}]([\text{a fish}])\rrbracket(\llbracket[\text{ catch and eat }]\rrbracket) = \lambda f[\exists x.\mathbf{fish}(x) \wedge [\exists e.\mathbf{catch}(e) \wedge f(e) \ \wedge \ \mathbf{th}(e) = x] \wedge [\exists e'.\mathbf{eat}(e') \wedge f(e') \ \wedge \ \mathbf{th}(e') = x]]$

This derivation involves conjoining the verbs directly, and applying the thematic role head to the object before the result is applied to the conjunction.

As for the "two-fish" reading, for those speakers that have it, we can generate it by adding an additional lexical entry for our silent theme head into the grammar – call it [th2]. This entry combines first with the verb and then with the object, rather than the other way around as [th] does. To generate the "two-fish" reading, we first attach [th2] to each of the verbs, then use Gazdar's entry to intersect the meanings of the resulting constituents, and finally apply the conjunction to the object quantifier. Here, we exploit the fact that our theme heads expect their arguments to be of type $\langle et, t\rangle$, similarly to the transitive verbs in Montague (1973). The full derivation of the verb phrase is as follows:

(50) a. $\llbracket[\text{th2}]\rrbracket = \lambda V \lambda Q \lambda f[Q(\lambda x[V(\lambda e[f(e) \ \wedge \ \mathbf{th}(e) = x])])]$
b. $\llbracket\text{catch}\rrbracket = \lambda f.\exists e.\mathbf{catch}(e) \wedge f(e)$
c. $\llbracket[[\text{th2}]\text{ catch}]\rrbracket = \lambda Q \lambda f[Q(\lambda x[\exists e.\mathbf{catch}(e) \wedge [f(e) \ \wedge \ \mathbf{th}(e) = x]])]$
d. $\llbracket[[\text{th2}]\text{ eat}]\rrbracket = \lambda Q \lambda f[Q(\lambda y[\exists e'.\mathbf{eat}(e') \wedge [f(e') \ \wedge \ \mathbf{th}(e') = y]])]$
e. $\llbracket[[[\text{th2}]\text{ catch}]\text{ and }[[\text{th2}]\text{ eat}]]\rrbracket = \lambda Q \lambda f[Q(\lambda x[\exists e.\mathbf{catch}(e) \wedge [f(e) \ \wedge \ \mathbf{th}(e) = x]])] \sqcap \lambda Q \lambda f[Q(\lambda y[\exists e'.\mathbf{eat}(e') \wedge [f(e') \ \wedge \ \mathbf{th}(e') = y]])]$

= $\lambda Q.\lambda f.[Q(\lambda x[\exists e.\mathbf{catch}(e) \wedge [f(e)\ \wedge\ \mathbf{th}(e) = x]])$
$\wedge Q(\lambda y[\exists e'.\mathbf{eat}(e') \wedge [f(e')\ \wedge\ \mathbf{th}(e') = y]])]$

f. ⟦[a fish]⟧ = $\lambda P \exists x.\mathbf{fish}(x) \wedge P(x)$

g. ⟦(50e)⟧(⟦(50f)⟧) = $\lambda f.$
$[\exists x.\mathbf{fish}(x) \wedge \exists e.\mathbf{catch}(e) \wedge f(e)\ \wedge\ \mathbf{th}(e) = x]$
$\wedge[\exists y.\mathbf{fish}(y) \wedge \exists e'.\mathbf{eat}(e') \wedge f(e')\ \wedge\ \mathbf{th}(e') = y]$

Since we have made use of the [th2] lexical entry here but we have left the entry of the verb unchanged, we can make [th2] available on a per-speaker basis. For example, the grammars of M. Rooth, B. Partee, and M. Bittner (or of the speakers they consulted) have only one lexical entry for the theme head, namely [th], while the grammars of H. Hendriks and Y. Winter have two, namely [th] and [th2].

Let us now withdraw the assumption that the same thematic role is involved in the catching and in the eating. The derivation of the "two-fish" reading involves the application of two thematic heads [th2], as shown in (50e). We could easily replace each of them by a different verb-specific theta role head whose meaning is identical to [th2] except for the relation involved. The "one-fish" reading as it has been derived in (49) involves the application of only one thematic head and so it cannot be retrofitted to accommodate two different thematic roles. Instead, we need to provide a third type of entry, one that can combine with verbs as in (50) but that does not assume that its argument is quantificational. After the two verbs combine with their role heads, they are coordinated by intersective conjunction, and the result is prepared for the quantificational argument by an application of Value Raising, a generalization of the Montague-lift (Hendriks, 1993).

This is illustrated in the following derivation, where [pre] stands for the thematic role head that denotes the thematic relation *prey*, which holds between a catching event and the entity caught in it, and [foo] stands for the head that denotes the thematic relation *food*, which holds between an eating event and the entity eaten in it. I write [vr] for my approximation of Value Raising. I only give the specific instantiation of Value Raising that is needed in this case, rather than the general rule.

(51) a. ⟦[pre]⟧ = $\lambda V \lambda x \lambda f.V(\lambda e[f(e)\ \wedge\ \mathbf{prey}(e) = x])$
b. ⟦[foo]⟧ = $\lambda V \lambda x \lambda f.V(\lambda e[f(e)\ \wedge\ \mathbf{food}(e) = x])$
c. ⟦[[pre] catch]⟧ = $\lambda x \lambda f.\exists e.[\mathbf{catch}(e) \wedge f(e)\ \wedge\ \mathbf{prey}(e) = x]$
d. ⟦[[foo] eat]⟧ = $\lambda x \lambda f.\exists e.[\mathbf{eat}(e) \wedge f(e)\ \wedge\ \mathbf{food}(e) = x]$
e. ⟦[[[pre] catch] and [[foo] eat]]⟧ = $\lambda x \lambda f.\exists e.[\mathbf{catch}(e) \wedge f(e)\ \wedge$ $\mathbf{prey}(e) = x] \wedge \exists e'.[\mathbf{eat}(e') \wedge f(e')\ \wedge\ \mathbf{food}(e') = x]$

f. $\llbracket$[vr]$\rrbracket$ = $\lambda A_{\langle e,\langle vt,vt\rangle\rangle}\lambda Q_{\langle e,et\rangle}\lambda f.\lambda e.Q(\lambda x.A(x)(f)(e))$

g. $\llbracket$(51f)$\rrbracket$($\llbracket$(51e)$\rrbracket$) = $\lambda Q.\lambda f.\exists e.Q(\lambda x.[\mathbf{catch}(e) \wedge f(e) \;\wedge\; \mathbf{prey}(e) = x] \wedge \exists e'.[\mathbf{eat}(e') \wedge f(e') \;\wedge\; \mathbf{food}(e') = x])$

h. $\llbracket$[a fish]$\rrbracket$ = $\lambda P \exists x.\mathbf{fish}(x) \wedge P(x)$

i. $\llbracket$(51g)$\rrbracket$($\llbracket$(51h)$\rrbracket$) = $\lambda f.\exists e.\exists x.\mathbf{fish}(x) \wedge [\mathbf{catch}(e) \wedge f(e) \;\wedge\; \mathbf{prey}(e) = x] \wedge \exists e'.[\mathbf{eat}(e') \wedge f(e') \;\wedge\; \mathbf{food}(e') = x]$

What this derivation shows is that the assumption that thematic roles are verb-specific (and the weaker assumption that the same argument can stand in two different thematic relations to two conjoined verbs) can be accommodated, although this requires us to assume thematic role heads of a new semantic type, and it requires Value Raising or a similar adjustment.

One noteworthy feature of the derivation in (51) is that it keeps track of the two different thematic roles in the right way. That is, the resulting denotation for *caught and ate a fish* combines the catching event with the prey relation, and the eating event with the food relation. In this way, the semantics mirrors and preserves the syntactic relationship between the verb *catch* and the thematic role head [pre], and the one between the verb *eat* and the thematic role head [foo]. Each of these syntactic relationships is local and can be enforced by whatever syntactic mechanism takes care of subcategorization. That the semantics keeps track of these relationships is an improvement over the system in Lasersohn (1995). That system does not specify a mechanism to keep track, and is criticized for this reason by Winter (2001, p. 43). Sentence (52) is discussed by Winter as being problematic for Lasersohn's account. I provide a derivation below. It is parallel to (51) above, except that we do not need to apply value raising since the subject is not a quantifier. For consistency with Lasersohn and Winter, I represent the thematic role heads involved as $\Theta_{\textit{sing}}$ and $\Theta_{\textit{dance}}$.

(52) John sang and danced.

a. $\llbracket\Theta_{\textit{sing}}\rrbracket$ = $\lambda V \lambda x \lambda f.V(\lambda e[f(e) \;\wedge\; \mathbf{singer}(e) = x])$

b. $\llbracket\Theta_{\textit{dance}}\rrbracket$ = $\lambda V \lambda x \lambda f.V(\lambda e[f(e) \;\wedge\; \mathbf{dancer}(e) = x])$

c. $\llbracket$[[$\Theta_{\textit{sing}}$] sing]$\rrbracket$ = $\lambda x \lambda f.\exists e.[\mathbf{sing}(e) \wedge f(e) \;\wedge\; \mathbf{singer}(e) = x]$

d. $\llbracket$[[$\Theta_{\textit{dance}}$] dance]$\rrbracket$ = $\lambda x \lambda f.\exists e.[\mathbf{dance}(e) \wedge f(e) \;\wedge\; \mathbf{dancer}(e) = x]$

e. $\llbracket$[[[$\Theta_{\textit{sing}}$] sing] and [[$\Theta_{\textit{dance}}$] dance]]$\rrbracket$ = $\lambda x \lambda f.\exists e.[\mathbf{sing}(e) \wedge f(e) \;\wedge\; \mathbf{singer}(e) = x] \wedge \exists e'.[\mathbf{dance}(e') \wedge f(e') \;\wedge\; \mathbf{dancer}(e') = x]$

f. $\llbracket$John$\rrbracket$ = j

g. $\llbracket$(52e)$\rrbracket$($\llbracket$(52f)$\rrbracket$) = $\lambda f.\exists e.[\mathbf{sing}(e) \wedge f(e) \;\wedge\; \mathbf{singer}(e) = j] \wedge \exists e'.[\mathbf{dance}(e') \wedge f(e') \;\wedge\; \mathbf{dancer}(e') = j]$

This last step, (52g), is the meaning of the sentence radical, and it holds of any set of events just in case it contains a singing event whose singer is John, and a dancing event whose dancer is John. As before, we can then either immediately apply closure, or if we want to model the contribution of tense, we can apply a semantic tense morpheme in order to require the two events to be contained in the reference time.

Let me now discuss Lasersohn's treatment of *alternately*, since he takes it as motivation for the collective theory of coordination, and specifically for the view that *sing and dance* denotes a predicate which is true of collective events that consist of a singing and a dancing. I will show how Lasersohn's treatment can in fact be implemented in the present system even though I have adopted the intersective theory of coordination rather than the collective theory. Lasersohn takes *alternately* to denote a modifier of event predicates, as shown in the following entry (Lasersohn, 1995, p. 274). Here P is a predicate of events, X is a collective event, τ is the runtime function, and $\circ$ denotes overlap. Collective events are modeled as sets. (Lasersohn adds the condition $e \notin P$ for theory-internal reasons that are irrelevant for the present purpose.)

(53) $X \in [\![\text{alternately}]\!](P)$ iff $X \in P \wedge \forall e, e' \in X[e \notin P \wedge \neg[\tau(e) \circ \tau(e')]]$

Lasersohn assumes that a conjoined event predicate P like *sing and dance* denotes the set of all collective events $\{e, e'\}$ that contain a singing event e, a dancing event e', and nothing else. The effect of applying the entry in (53) to *sing and dance* consists in eliminating those pairs whose members have overlapping runtimes, and in particular those pairs whose members are simultaneous. The result is that a conjoined verb phrase of the shape *alternately P and Q*, where P and Q are action predicates, will hold of a subject x just in case x did one instance of a P action and one non-overlapping instance of a Q action. As Lasersohn notes, this can easily be modified if one feels that more than one instance of each type of action is necessary for alternation. I will come back to this point at the end of this section.

I now show how we can import Lasersohn's account into the present account by making use of set minimization, which allows us to simulate the effects of collective conjunction in an intersective framework (Winter, 2001; Champollion, 2014). Set minimization is defined formally as follows, where τ is any conjoinable type:

(54) $\mathbf{min} =_{def} \lambda V_{\tau t} \lambda A_{\tau}.\ A \in V \wedge \forall B \in V[B \subseteq A \rightarrow B = A]$

Minimization takes a set of sets V and returns the set of all those sets that are contained in V but that do not have any proper subsets that are contained in V. For example, when we intersect the generalized quantifiers that we obtain by value-raising the constants *John* and *Mary* and minimize the result, we get the set $\{\{j, m\}\}$.

Now let us apply set minimization to recover Lasersohn's collective events from our verb phrases. Take for example the conjoined verb phrase *sing and dance*, whose denotation is shown in (52e). For purposes of exposition, let us ignore for a moment the fact that the subject is abstracted over, and assume that it is already fixed to the individual John. Then the simplified denotation of *sing and dance* is as follows:

(55) $[\![\text{sing and dance}]\!]_{\textit{simplified}}$
$= \lambda f.\exists e.[\mathbf{sing}(e) \wedge f(e) \wedge \mathbf{singer}(e) = j] \wedge \exists e'.[\mathbf{dance}(e') \wedge f(e') \wedge \mathbf{dancer}(e') = j]$

This is the set of all sets that contain a singing event by John and a dancing event by John. The result of applying set minimization to this is the set of all *minimal* sets that contain a singing event by John and a dancing event by John. Assuming that no event is both a singing and a dancing event, this means that set minimization will return the set of all two-element sets that contain a singing event by John and a dancing event by John. This is precisely the denotation that Lasersohn attributes to the verb phrase *sing and dance*, as shown in (37b), repeated here as (56):

(56) $[\![\text{sing and dance}]\!]_{Lasersohn}$
$= \lambda e.\exists e_1 \exists e_2.\mathbf{sing}(e_1) \wedge \mathbf{dance}(e_2) \wedge e = \{e_1, e_2\}$

Putting the pieces together involves an additional step, since our denotation for *sing and dance* abstracts over the subject, as shown in (52e), repeated here as (57):

(57) $[\![\text{sing and dance}]\!] = \lambda x \lambda f.\exists e.[\mathbf{sing}(e) \wedge f(e) \wedge \mathbf{singer}(e) = x] \wedge \exists e'.[\mathbf{dance}(e') \wedge f(e') \wedge \mathbf{dancer}(e') = x]$

This difference to Lasersohn's account is what allowed us earlier to avoid the problem diagnosed for it by Winter (2001). It is the fact that we abstract over the subject that helps us keep track of the pairing of thematic roles with verbs.

My entry for *alternately*, shown in (58), combines with a verb phrase V of the type of the one in (57) and with a subject. The result can then be further modified by tense if desired, and closed off by the closure operator.

(58) $[\![\text{alternately}]\!] = \lambda V_{\langle e,\langle vt,t\rangle\rangle}\lambda x\lambda f\exists e_1\exists e_2.[\neg\tau(e_1)\circ\tau(e_2)]$
$\wedge\{e_1,e_2\}\in\mathbf{min}(V(x))\wedge f(e_1)\wedge f(e_2)$

For example, if we ignore tense, the meaning of *John alternately sang and danced* comes out as follows:

(59) $[\![\text{John alternately sang and danced}]\!] = \exists e_1\exists e_2.[\neg\tau(e_1)\circ\tau(e_2)]\wedge$
$\{e_1,e_2\}\in\mathbf{min}(\lambda f.\exists e.[\mathbf{sing}(e)\ \wedge\ \mathbf{singer}(e)=j]\wedge\exists e'.[\mathbf{dance}(e')\ \wedge$
$\mathbf{dancer}(e')=j])$

Given the above discussion about minimization, this is equivalent to the following:

(60) $\exists e_1\exists e_2.[\neg\tau(e_1)\circ\tau(e_2)]\wedge$
$\mathbf{sing}(e_1)\ \wedge\ \mathbf{singer}(e_1)=j\wedge\mathbf{dance}(e_2)\ \wedge\ \mathbf{dancer}(e_2)=j$

This is true just in case John sang and danced but not at the same time, as desired. Thus, Lasersohn's account of *alternately* can be implemented independently of whether one takes the meaning of verb phrase conjunction to be intersective (as I do) or collective (as Lasersohn does).

A final remark on *alternately*. As mentioned above, Lasersohn notes that his entry can easily be modified if one feels that more than one instance of each type of action is necessary for alternation. For example, *John alternately sang and danced* probably requires him to go through more than just one alternation (that is, a change from singing to dancing or the other way round). We can also modify the entry in (58) in the same way. For example, suppose that three alternations are required. To make things simpler, assume that state changes require temporal adjacency. John sings until a certain point, at which he stops singing and starts dancing. This could be relaxed if desired, but I will not do so. Let us say that event e_1 abuts event e_2, written $e_1 \supset\!\subset e_2$, iff the runtime of e_1 ends at the same time as the runtime of e_2 starts. The following entry ensures that three alternations are required.

(61) $[\![\text{alternately2}]\!] = \lambda C_{\langle e,\langle vt,t\rangle\rangle}\lambda x\lambda f\exists e_1\ldots e_4.[e_1\ \supset\!\subset\ e_2\ \supset\!\subset\ e_3\ \supset\!\subset\ e_4]\ \wedge$
$\{\{e_1,e_2\},\{e_2,e_3\},\{e_3,e_4\}\}\subseteq\mathbf{min}(C(x))\wedge f(e_1)\wedge\ldots\wedge f(e_4)$

This entry has the consequence, for example, that *John alternately sang and danced* is true iff there are four pairwise abutting events e_1 to e_4 such that each abutting pair in them is a minimal element of the set of sets *sing and dance*, that is, the pair consists of a singing and a dancing. These pairs overlap and thereby enforce alternation. For example, if e_1 happens to be a singing, then e_2 must be a dancing, which in turn means that e_3 must be a dancing again and so on. So we can capture the meaning of *alternately* correctly (as can Lasersohn) no matter how many alternations are felt to be required.

Summing up this section, the argument in Lasersohn (1995) that *alternately* favors the collective theory over the intersective theory does not go through. Assuming that Lasersohn's own theory can be amended to address the criticisms leveled against it by Winter (2001), adopting event semantics does not commit us to choosing one theory of coordination over another. In particular, adopting the intersective theory is compatible with event semantics.

6 Conclusion

I have shown that Neo-Davidsonian event semantics does not pose a particular problem for compositional semantics. It can be combined with standard accounts of quantification, be they syntactic or semantic. It furthermore allows us to use a standard translation of truth-functional linguistic negation in terms of logical negation, and it is equally compatible with intersective (boolean) and collective (non-boolean) accounts of coordination. Previously, event semantics had been considered problematic for syntactic accounts of quantification and for classical accounts of negation (Beaver and Condoravdi, 2007; Krifka, 1989). It had also been suggested that event semantics is more amenable to collective than to intersective accounts of coordination (Lasersohn, 1995).

The specific framework proposed here differs from business as usual only in that it places existential closure of the event variable inside the verb, rather than at sentence level. This then provides a simple account for the fact that quantifiers always take scope above existential closure, a fact which is difficult to model otherwise since it requires stipulating that quantificational arguments obligatorily take wide scope. Such a claim would be problematic especially in case of languages where quantifiers otherwise take scope in situ, such as Chinese (S.-F. Huang, 1981; C.-T. J. Huang, 1998). By making it possible to interpret all quantifiers in situ, the framework proposed here combines the strengths of event semantics and type-shifting accounts of quantifiers and thus does not force the semanticist to posit either a default underlying word order or a syntactic LF-style level. It is therefore well suited for applications to languages where word order is free and quantifier scope is determined by surface order. Unlike the accounts in Beaver and Condoravdi (2007) and Eckardt (2010), it is completely standard in its assumptions and its underlying logic and should therefore be highly compatible with accounts of other phenomena formulated in the literature.

Note

The formal system presented in this paper has been developed with the help of the Lambda Calculator (Champollion, Tauberer, and Romero, 2007). This software tool has also been used to check the derivations for correctness and to generate the figures in this paper. Information on the calculator, as well as a basic version of the tool, is available at `http://www.lambdacalculator.com`. Please contact me via email at `champoll@gmail.com` for a more advanced version of the calculator, along with a file that implements the formal system and derivations presented here.

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