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Abstract

This paper concerns the analysis of adverbial and PP modifiers of VP suggested by Davidson, where verbs are regarded as introducing reference to events, and such modifiers are predicates of these events. Several problems raised by it are described and a solution is presented. The paper then goes on the suggest some extensions of the theory in order to be able to cope with temporal and aspectual modification of VPs.

Events and Verb Phrase modifiers

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Introduction

Davidson (1980) proposes an analysis of adverbial modifiers (by which he means adverbial and prepositional phrases) which involves giving verbs an extra argument place describing an event. Adverbial modifiers are then predicates of this event. Where the modifier is a derived adverb, the predicate is simply the corresponding adjective. Thus a sentence like:

1. Jones buttered the toast slowly, deliberately, in the bathroom, with a knife, at midnight

is to be partly translated as:

2. $\exists e$ butter(Jones, the toast, e) $\wedge$ in(e, the bathroom) $\wedge$ with(e, a knife) $\wedge$ at(e, midnight)

paraphrased 'there was a buttering by Jones of the toast event and that event was in the bathroom, at midnight and with a knife'. This analysis solves two problems posed by such constructions: that modifiers can be iterated virtually indefinitely, and that each successively modified version of the sentence entails the original version: if Jones buttered the toast slowly, then Jones buttered the toast. If Jones buttered the toast slowly in the bathroom, then Jones buttered the toast slowly, and so on. Both of these properties now follow from those of conjunction.

Davidson's analysis has been very influential in computational linguistics, since it leads to analyses which, being first order, are computationally tractable. However, there are several well known problems that it encounters, and some types of verbal modification that it appears unable to deal with. This paper discusses three of these and proposes some modifications and extensions to the original theory.

1. Adjectives

Two modifiers in 1 are missing in 2: 'slowly' and 'deliberately'. This is because Davidson regarded adverbs like 'slowly' and 'deliberately' as not falling under his analysis: they cannot, he says, be simple predicates of events. His reason for this

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is that one and the same event might be slow, e.g. as a crossing of the Channel, and fast, as a swim:

3. Jones crossed the Channel slowly (by swimming quickly)

It would be a nonsense to say that there was an event that was both slow and fast.

A first reaction to this is that here we simply have a familiar property of many, if not all, adjectives. Adjectives are interpreted as if they have an implicit parameter referring to the relevant standard of comparison for the set of objects denoted by their subject 'Adj for an X'. Something is not tall, *tout court*, it is tall for a man, or for a building. It is arguable that even the simplest apparently intersective adjectives behave like this: the standards of redness for a cheek are different from those for a rose or a wine.

In fact, in the case of adjectives like 'slow', it appears that all the other arguments of the verb can be relevant, not just the subject: in

4. Jones crossed the street slowly, and in doing so crossed from France into Italy

we have an event that is slow for a crossing of the street, though possibly fairly fast for a crossing from one country into another.

Davidson himself was wedded to a strictly first order analysis of English. There is a long story to be told about why that cannot be the right way to go about things: here let me simply assert that the interesting features of the Davidsonian program are not compromised by ditching the first order requirement and using higher order logic. (There is of course a computational price to pay here). Once we have made this move, we can give these adverbials a translation which employs an extra parameter giving a full description of the type of event being considered.

5. Jones buttered some toast slowly

will translate as:

6. $\exists e \ \exists x$ (toast x) $\land$ (butter Jones, x, e) $\land$ slow(e, ($\lambda e'$ $\exists y$ $\exists z$ (toast y) $\land$ (butter y, z, e')))

'There was a buttering of the toast by Jones event, and by the standards of those events which are butterings of toast by someone, that event was slow'.

How does something of the form Adj(e, P) get interpreted semantically? If this line of argument is correct, then understanding the meaning of such adjectives involves knowing a function which for each adjective, and for each property, divides the objects in the domain of interpretation which possess the property, into those which fall into the extension of the adjective and those which don't. No doubt many refinements for this are needed, but this will do for a first pass. We will therefore assume given a function which enables us to use statements like this:

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7. Adj(e, P) is true iff Adj-fn (Adj, P, e) = t

Of course, in an actual implementation, we can recast the effects of such a function in terms of meaning postulates, or rules of inference, at least in the cases where the property in question is capable of being dealt with in a quantitative way. So we might encode something like 'tall' as:

greater-than (height-of (x), 100ft) → tall (x, tree)
greater-than (height-of (x), 6ft) → tall (x, person)

etc.

The other adverbial present in 1 but not 2 is 'deliberately'. Davidson regards this adverbial too as not wholly extensional, since it ascribes intention to the subject of the sentence. However, now that we have moved away from first order logic, it is at least possible for us to contemplate a treatment of notions like these, and in fact, elsewhere in the paper Davidson suggests paraphrasing 'deliberately' to explicitly make reference to the intentions of the subject:

8. Jones did p deliberately = It was intentional of Jones that Jones did p

Adopting this course we might translate 'deliberately' as:

9. deliberately = $\lambda vp\ \lambda e\ \lambda x\ ((vp\ e)\ x) \wedge$ (intentional-of x, ((vp e) x))

Now a sentence like:

10. Jones coughed deliberately

will translate as:

11. $\exists e$ (cough Jones, e) $\wedge$ (intentional-of Jones (cough Jones e))

'There was a coughing by Jones and that coughing by Jones was intentional of Jones'.

Of course, we still need to say what the interpretation of 'intentional' is. I have no concrete suggestions along these lines to make here, but I assume that there is a good chance that logics of the type developed by Cohen, Perrault, Levesque and their colleagues can supply enough connections between this notion and those of having goals, desires and beliefs for us to be able to make some progress here (see, for example, Cohen and Levesque 1985).

The following fragment of CF grammar with associated semantic expressions will produce all the translations suggested so far. Notice that here, as thoughout, all functions are curried:

S → NP VP : $\exists e$ NP (VP e)
VP → Vi : Vi
VP → Vt NP : (Vt NP)

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VP → VP Adv : (Adv VP)
VP → VP PP : λe λx ((VP e) x) ∧ (PP e)
PP → P NP : (P NP)
NP → Name : λP (P Name)
NP → Det N : (Det N)

Vt: λnp λe λx (np (λy (Vt x y e)))
Vi : λe λx (Vi x e)
P: λnp λx (np (λy (P x y)))
Det: e.g. λP λQ ∀x Px → Qx etc.
Adv: Adj-ly = λvp λe λ x ((vp e) x) ∧ (Adj e (λe' ∃x' ((VP e') x')))

However, there is one respect in which the suggested treament of 'intentionally'
will not give the right results: if we assume that passive VPs are translated thus:

12. be arrested = λe λy ∃x (arrest x, y, e)

then in a sentence like:

13. The demonstrators were arrested/provoked deliberately

it will be the demonstrators who had the relevant intention. This is plausible here
(more so for the 'arrested' than the 'provoked' version) but the reading on which
the implicit agent had the intention is also possible. It is not clear how to contrive
that this happens. One possibility might be to predicate 'deliberate' of events
directly, just like other adverbs, and make the necessary ascription of intention to
an agent via meaning postulates and inference in a particular context. Thus given
a logical form like:

14. ∃e (cough Jones, e) ∧ (deliberate e)

and a postulate like:

15. ∀e (deliberate e) → ∃x (intentional-of x (happen e))

we would simply say that if an event is deliberate then somebody had an inten-
tion that it should happen. For most verbs, this will be the agent. 'Happen' is
eliminable: an event happens if there is some time that that event is at:

16. ∀e (happen e) ↔ ∃t (at e, t)

2. Quantifier Scope

I now turn to a problem in the event analysis of VP modifiers concerning quantifier
scope. Examples like 17a are plausibly regarded as ambiguous, between a single
event that was quick, and a series of quick events. 17 b and c are biased towards
one or the other reading:

17a. Jones quickly telephoned every customer
  b. Quickly, Jones telephoned every customer
  c. Jones telephoned every customer quickly

On Davidson's original theory the single event reading can be formalised as:

18. $\exists e \forall x$ (customer x) $\rightarrow$ (telephone Jones, x, e) $\wedge$ (quick e)

Unfortunately, this logical form entails the other reading:

19. $\forall x$ (customer x) $\rightarrow \exists e$ (telephone Jones, x, e) $\wedge$ (quick e)

This is stronger than we want: 19 is compatible with 18, but should not be entailed by it: it might be the case that the overall event was quick even though the telephoning of one or two of the customers was slow.

One suggestion is that we should try to formalise some notion of a 'minimal' event, to try to block the inference from 18 to 19. Thus adverbials might be treated thus:

20. $\forall x$ ((Adj-ly P) x) $\leftrightarrow$ (P x) $\wedge$ (Adj x) $\wedge \neg\exists y$ (P y) $\wedge$ (in y x)

Then 18 would translate as:

21. $\exists e \forall x$ (customer x) $\rightarrow$ (telephone Jones, x, e) $\wedge$ (quick e) $\wedge \neg\exists y$ (telephone Jones, x, y) $\wedge$ (in y e)

Unfortunately, this still doesn't block the inference to:

22. $\forall x$ (customer x) $\rightarrow \exists e$ (telephone Jones, x, e) $\wedge$ (quick e) $\wedge \neg\exists y$ (telephone Jones, x, y) $\wedge$ (in y e)

and is in any case too strong. In a sentence involving an activity verb, we do not want to rule out the existence of subevents of the same type, which may have the same properties:

23. Jones ran quickly
24. $\exists e$ (run Jones, e) $\wedge$ (quick e) $\wedge \neg\exists y$ (run Jones, y) $\wedge$ (in y e)

24 is too strong as a translation of 23: the defining characteristic of activity verbs is that they do contain subevents of the same type, down to a certain level, and some of these subevents might also have been quick (in fact, some of them must have been).

The problem here is again caused by the omission of the contextual parameter for the adjective meaning. If this is put in, then the readings which represent the different quantifier scopings will give rise to different values for this parameter, preventing the unwanted inference from going through - there will be different types of quickness involved.

If we assume that some form of quantifier raising mechanism is in operation, operating so as to raise an NP meaning corresponding to a quantifier in the following way:

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25. ... $[\lambda Q.Q—]$ ... $\Rightarrow$ $[\lambda Q.Q—](\lambda q.$ ... $[\lambda R.Rq]$ ...$)$

where the position occupied by the NP is marked by the λq variable, raised to the type of an NP by the λR, then the translation for adverbs suggested above will give us the results we need. The logical form which quantifier raising will operate on will be:

26. $\exists e.\ [\lambda P.P\ \text{Jones}]$
$([\text{quickly}([\lambda np\lambda e'\lambda x.(np(\lambda y.\text{telephone}\ x\ y\ e'))])]$
$(\lambda Q.\forall z.\text{customer}\ z \to Qz))]\ e)$

giving:

27. $[\lambda Q.\forall z.\text{customer}\ z \to Qz]$
$(\lambda q.\ \exists e.[\lambda P.P\ \text{Jones}]$
$([\text{quickly}([\lambda np\lambda e'\lambda x.(np(\lambda y.\text{telephone}\ x\ y\ e'))])](\lambda R.Rq))]\ e))$

Given the translation of 'quickly' as:

28. $\lambda vp\lambda e1\lambda x'.((vp\ e1)\ x') \wedge \lambda\ \text{quick}(e1\ (\lambda e2.\exists y'.((vp\ e2)y')))$

the first unraised form will reduce to:

29. $\exists e.\ \forall x.\text{customer}(x) \to \text{telephone}(\text{Jones}\ x\ e) \wedge$
$\text{quick}(e\ [\lambda e2.\ \exists y.\ \forall z.\ \text{customer}\ z \to \text{telephone}\ y\ x\ e2])$

'There was an event such that for every customer, Jones telephoned the customer, and that event was quick by the standards of those events that are telephonings of every customer by someone'.

The second, quantifier raised version reduces to:

30. $\forall z.\ \text{customer}(z) \to$
$\exists e.\ \text{telephone}(\text{jones}\ z\ e) \wedge \text{quick}(e\ [\lambda e'.\ \exists y.\ \text{telephone}(y\ z\ e')])$

'For every customer, there was an event of Jones telephoning the customer, and that event was quick by the standards of those events which are telephonings of that customer by someone'.

Now our problem is solved, for there is no unwanted inferential relationship between the two alternative readings.

3. Events and States

Here is another problem. The intuitive notion of event is that events are things which happen at particular places and times. But many sentences do not describe things that happen, so much as states of affairs that obtain, where the state need not be associated with any particular place and may persist through long periods of time. And these sentences seem to behave in relevant respects like our event sentences, taking VP modifiers, displaying quantifier scope ambiguities, etc.

31. Jones lived in London quietly
32. Jones owned every Hockney in London for a year (at once/in turn)

The problem of how to give a logical form for these sentences is fairly easily solved by adding to our ontology the requisite notion of state, which will behave as far as compositional semantics is concerned, exactly like events.

However, this still isn't enough: there are many sentences where reference to both a state, and an event resulting in that state, seems to be being made:

33. Jones hired a car for two weeks
34. Jones almost ran a mile

In 33 the most natural reading is that the period for which Jones possessed (or perhaps intended to possess) the car - the resulting state - lasts for two weeks, not that the event of hiring lasted two weeks. In 34, either Jones ran, but didn't quite finish a mile, or he didn't run at all. 'Almost' can be taken to be modifying either the event or the resulting state. To account for phenomena like these we seem to need to go inside the situation described by the sentence and be able to modify components of that overall situation.

In Pulman (1977) I developed a theory within a Davidsonian framework according to which sentences described either events, actions, or events or actions resulting in states. Events were not divisible, whereas actions were: down to a certain level, actions could be seen as consisting of many instances of the same sub-action. The intention was to trade on the often observed similarity of contrast between plurals and mass vs count nouns on the one hand, and process vs punctual verbs on the other, and also to account for many aspectual phenomena in terms of restrictions on what type of ontological category particular modifiers could combine with.

Now that we have both events and states, we can help ourselves to a theory of plurality (from Link 1983) which allows us to contemplate a somewhat different formalisation of this theory on which many of the desired properties fall out from the logic itself. (See also Bach 1986 for related suggestions).

There is not space to go into all the formal details here, (even if they had all been fully worked out), but the essential features of the approach can be conveyed informally. We have atomic events, and plural or complex events. The theory put forward by Link enables us to form complex plural individuals from singular individuals of any type, events and states included. What I was calling actions now correspond to plural events. Their 'homogeneity' property then immediately follows from the nature of plurals (see Link 1983). Events, as in the original Davidson story, are just individuals like any other, whether plural or singular, likewise with states. The revised classification now looks like this:

state: own a car, live in London, like Mozart
atomic-event: blink, sneeze, cough
plural-event: run, drive a car, listen to Mozart
event+state: notice the picture, recognise Jones, hire a car,
build a house, write a thesis, recover from illness

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This, as will be obvious, is similar to the well known Vendler classification, except that it is better regarded as a classification of ways people have of viewing situations, rather than of linguistic entities like verbs or sentences.

The idea now is that particular aspects and types of modifier are things which are 'sorted'; that is to say, they are functions which require their arguments (and outputs) to occupy a particular ontological slot. For example, a 'for ...' temporal adverbial requires its argument to be something capable of occupying a period of time. This requirement (although I do not know how to formalise this precisely) we will assume to be satisfied by states but not atomic events. Thus the preferred reading of sentence 33 is that on which the 'for' phrase modifies the 'state' part of the 'hiring a car' situation, not the atomic event part. The resulting ontological category is that of another event: the event which consists of Jones having hiring a car for a week, where this retains the internal structure revealed by the interpretation of the modifier.

If the sortal requirements are not satisfied, it is possible for a process of 'coercion' to take place. (See also Moens and Steedman 1986, who take an approach which is similar in spirit). For example, we can apply an 'iterate' function to an atomic event which results in a series of such events capable of occupying a period of time, or alternatively a 'stretch' function which focuses on the normally unavailable internal structure of it, which thereby also becomes seen as extended in time.

Here is a short promissory note to illustrate how an analysis in these terms might proceed:

The progressive takes a state, or an event which it redescribes as a state, and says that the state obtained at whatever time the sentence refers to.

The perfect takes an event or a state and says, to a first approximation, that whatever state resulted from that persists to the time referred to in the sentence.

This can be best illustrated informally by glossing the following examples.

    35. Jones is hiring a car

The progressive takes the event part of this event+state combination, makes a state out of it and says that that state obtains now. (There is always the simple future reference use of progressives: ignore this).

    36. Jones has hired a car

There was an instance of this event+state combination and the state resulting from it persists to the present.

    37. Jones has hired a car for a week

There was an event consisting of an event+state combination, where the state satisfied 'for a week' and a state resulting from that event persists to the present.

In cases where it is not very plausible pragmatically that events can be redescribed as states, the coercing functions might be used. Thus

38. Jones was sneezing for a week

most naturally has the iterative interpretation. It is also possible, though desperately implausible in most contexts, to get the 'slow motion' reading induced by the 'stretch' coercing function. In fact, with ingenuity it is also possible to find similar readings in sentences like 33 and 37.

The idea is that these various operators and functions build up to determine the final ontological status of a sentence in a way which, modulo coercion, is compositional. If this is correct, then we should be able to reduce much of the complexity of more traditional analyses to simple predications about events and states, which possibly contain reference to other events and states.

4. Conclusion

Clearly, much more work needs to be done before this kind of treatment could be regarded as a contender to other analyses of these phenomena currently available. However, I am optimistic about the prospects for the approach advocated here. The marriage of the Davidsonian analysis of verbs, with existing logics of mass terms and plurals, plus an intuitively quite natural expansion of our ontology to include states as well as events promises to provide an elegant and unifying approach to the semantics of these constructions, and one which does justice to the intuitions of many people that these apparently different areas of semantics actually have some deep underlying connection.

Acknowledgments

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