Event Semantics with Dependent Types

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This paper studies how dependent types can be employed in describing event types. It is shown that this offers a nice treatment of Davidson's event semantics in modern type theories and, as a positive consequence, gives a natural solution to the incompatibility problem in combining event semantics with the traditional Montague semantics (the so-called event quantification problem).

Event Semantics and Dependent Types: Introduction. The event semantics, whose study was initiated by Davidson [3] and further studied in its neo-Davidsonian turn (see [7] among others), has several notable advantages including Davidson's original motive to provide a satisfactory semantics for adverbial modifications. Dependent types, as those found in modern type theories (MTTs) such as Martin-Löf's type theory [6], may provide a useful tool in formalising event types.

We argue that event types can naturally be formalised as dependent types and this extends MTT-semantics [8, 5] effectively with events – we shall demonstrate how VPs are interpreted in MTT-semantics with events. As a positive consequence of such a treatment of events, we shall show that the so-called event quantification problem [2, 9] is resolved naturally in the setting with dependent event types.

Dependent event types, or indexed event types, were first considered in an example in [1] to study linguistic coercions in formal semantics, where types of events are indexed by their agents: $Evt(h)$ is the type of events conducted by $h : Human$. In this paper, we shall study a more general setting for formal semantics with events in modern type theories.

Dependent Types of Events. Rather than a single type $Event$ of events, as in the Davidsonian event semantics in the traditional Montagovian setting [3, 7], we consider types $Evt(\bar{t})$ of events indexed by some parameters $\bar{t} = t_1, ..., t_n$. In this abstract, we only consider examples with $n = 1, 2$: either $Evt : Agent \to Type$ or $Evt : Agent \to Patient \to Type$. The indices of events can be recovered: for example, there are definable functions AGENT and PATIENT so that, for any event $e : Evt(a, p)$, $\text{AGENT}(e) = a$ and $\text{PATIENT}(e) = p$.[1]

For example, consider (1). In the traditional event semantics in the simple type theory, (1) is interpreted as (2), while in our setting with dependent types of events, its interpretation is (3) where the type $Evt(j, m)$ of the additional event argument depends on John and Mary.

(1) John kissed Mary passionately.

(2) $\exists e : Event.\ kiss(e)\ \&\ agent(e, j)\ \&\ patient(e, m)\ \&\ passionate(e)$

(3) $\exists e : Evt(j, m).\ kiss(e)\ \&\ passionate(e)$

VPs in MTT-semantics with Events. In the MTT-semantics, CNs are interpreted as types and, as a consequence, VPs do not have a single type $e \to t$; instead, a VP has a domain whose objects can meaningfully act as the subject of the VP. For example, $talk : Human \to Prop$ in the ordinary MTT-semantics. When we have events, a VP is given a dependent type; for instance, $talk$ is given a type as in (4) and the sentence (5) will be given semantics in (6):

(4) $talk : \Pi h : Human.\ Evt(h) \to Prop.$

[1] One can study the relationships between event types. For example, in many situations, it may be natural to have $Evt(a, p) \leq Evt(a)$, that is, the type of events with agent a and patient p is a subtype of that with agent a.

(5) John talked loudly.

(6) $\exists e : Evt(j).\ talk(j, e)\ \&\ loud(e)$

Event Quantification Problem. It has been argued that there is some incompatibility between (neo-)Davidsonian event semantics and the traditional compositional semantics [2, 9]. De Groote and Winter [4] have dubbed this as the *event quantification problem.* Consider the following sentence (7) which, under the traditional event semantics, could have two possible interpretations (8) and (9), where (9) is incorrect.[2]

(7) No dog barks.

(8) $\neg\exists x{:}Dog\ \exists e{:}Event.\ bark(e)\ \&\ agent(e, x)$

(9) $(\#)\ \exists e{:}Event.\ \neg\exists x{:}Dog.\ bark(e)\ \&\ agent(e, x)$

In order to avoid such incorrect interpretations, people have made several proposals (see, for example, [2, 9]) which involve, for instance, consideration of quantification not over events but over sets of events [2], or some principles whose adherence would disallow the incorrect interpretations.

In our setting with dependent types of events, (7) will be interpreted as (10), while the 'incorrect' interpretation (11) is not available (the proposition (11) is ill-typed because x in $Evt(x)$ is outside the scope of $x{:}Dog$)!

(10) $\neg\exists x{:}Dog\ \exists e{:}Evt(x).\ bark(e)$

(11) $(\#)\ \exists e{:}Evt(x).\ \neg\exists x{:}Dog.\ bark(e)$

It is worth emphasising that, with dependent event types, the event quantification problem be resolved naturally because, in this setting, the incorrect solution is simply impossible (ill-typed).

Further Developments. In the full paper, we shall also investigate and discuss several further issues concerning the following questions: (1) What are the subtype relationships between event types? (2) How to understand the sameness of events? and (3) Should general thematic roles be parameters of event types? Dependent event types provide us with a framework that possibly offers new insights into these issues.

References

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[2] Here we have considered dogs to form a domain type *Dog* for an easier comparison with the MTT-semantics in (10-11). One could have used predicates for CNs and then, for example, (8) would become: $\neg\exists x.\ [dog(x)\ \wedge\ \exists e.\ bark(e)\ \&\ agent(e, x)]$.