Logical Complexity in Aspect

Peter Hallman, University of Vienna

and the Austrian Research Institute for Artificial Intelligence

peter.hallman@univie.ac.at

Abstract

The paper formulates and defends the claim that the difference between stative and eventive predicates is type-logical, not sortal. Stative predicates hold only at moments, which are temporal primatives, while eventive predicates hold only at intervals, which are sets of moments. Since intervals are more complex than moments, eventive predicates have a higher logical type than stative predicates, to which differences in their distribution are traced. Evidence is presented that temporal dimensionlessness is what progressive predicates have in common with stative predicates in general, explaining the otherwise puzzling stativity of progressive predicates, though the underlying verb phrase is necessarily eventive. It is shown how this view of the progressive extends to certain constructions in which modality interacts with the state/event distinction. The analysis is also defended against prior criticisms of the appropriateness of dimensionless temporal coordinates in natural language semantics.

1 Introduction

In this paper, I claim that the difference between stative and eventive predicates is one of type-logical complexity: stative predicates hold only at moments in time, while eventive predicates hold only at intervals (sets of moments). The difference in complexity between moments and intervals (intervals consist of what moments are) is the source of differences in the distribution of stative and eventive predicates. In section 2, I motivate this view as a solution to the puzzle of why progressive predicates are stative, though the underlying verb phrase is eventive, and sketch a theory of aspect based on this view of the state/event distinction. Section 3 then defends this theory from philosophical criticisms of moments in natural language semantics.

2 A type-logical analysis of the state/event distinction

In this section, I claim that the fact that progressive predicates are stative presents a dilemma for conventional theories of the progressive. A way out of this dilemma, I suggest, is found in the idea that progressive predicates hold only at moments of time, and never at intervals. I then claim that the reason why progressive predicates pattern semantically together with stative predicates is that being a moment-description is the defining property of stativity.

Vendler (1957) shows that predicates fall into four classes based on their compatibility with the progressive on one hand and their compatibility with temporal adverbials headed by the preposition *in*, such as *in an hour*, on the other. Those that are compatible with both the progressive and with *in an hour* he calls 'accomplishments'. Those that are compatible with the progressive but not with *in an hour* he calls 'activities'. Those that are incompatible

with the progressive but compatible with *in an hour* he calls 'achievements'. Those that are compatible with neither the progressive nor with *in an hour* he calls 'states'.

(1) a. Mary was drawing a circle. [Accomplishment]

b. Mary drew a circle in an hour.

(2) a. Mary was drawing. [Activity]

b. *Mary drew in an hour.

(3) a. *Mary was reaching the top. [Achievement]

b. Mary reached the top in an hour.

(4) a. *Mary was seeing the star. [State]

b. *Mary saw the star in an hour.

Many diagnostics group the three non-stative aspectual classes together. I refer to these predicates as 'eventive'. For example, in English, stative predicates are fully acceptable in the simple present tense, while eventive predicates are marginal except under a habitual or generic reading. The '*' in (5a)-(5c) indicates ungrammaticality on a reading analogous to the present continuous reading of the stative predicate in (5d).

(5) a. *Mary draws a circle. [Accomplishment]

b. *Mary draws. [Activity]

c. *Mary reaches the top. [Achievement]

d. Mary sees the star. [State]

Eventiveness is also a necessary condition for occurrence in the progressive. However, the progressive derivative of an eventive predicate patterns aspectually like a stative predicate (Vlach 1981, Bach 1986, Mittwoch 1988, Condoravdi 2002, Stowell 2007, and others). That is, though *draw a circle* is eventive, *be drawing a circle* is stative. In terms of Vendler's diagnostics, progressive predicates are incompatible with *in an hour* (6a), but cannot themselves be put in the progressive (6b). Other respects in which progressives pattern like stative predicates are discussed below.

(6) a. *Mary was drawing a circle in an hour.

b. *Mary was being drawing a circle.

Davidson (1967) claims that events are potential objects of linguistic reference and that eventive predicates are descriptions of these objects. A sentence like *Shem kicked Shaun* has the logical form in (7), which asserts that there is an event e which Shem and Shaun stand in the 'kicked' relation to.

(7) $\exists e$ kicked(Shem, Shaun, e)

According to Davidson, stative predicates differ from eventive predicates in lacking an event argument. Subsequent research, however, has drawn the conclusion that stative predicates also have an aspectual argument (Parsons 1990, Kamp and Reyle 1993, Mittwoch 2005, Landman 2000). On this view, stative and eventive predicates differ not in their argument structure, but in the kind of aspectual argument they describe. A 'sortal' theory of the state/event distinction holds that states and events are different sorts of individuals in the

universe of discourse. Eventive predicates have an 'event argument' while stative predicates have a 'state argument'. Both events and states are individuals, i.e. zero degree order semantic objects. I follow the practice originating with Bach (1981) of referring to states and events collectively as 'eventualities'.

On the view that stative predicates are descriptions of states, and eventive predicates descriptions of events, differences in the distribution of eventive and stative predicates derive from differences between events and states themselves. A common and intuitive characterisation of the difference is that states are static while events are dynamic (e.g. Taylor 1977). The formulas in (8) define stative and eventive predicates along these lines. A predicate is stative if it holds of every subpart of its eventuality argument (8a). That is, it describes an eventuality that entirely homogeneous with respect to the predicate description. If this is so, the eventuality does not exhibit any change in the property the predicate denotes. It is 'static' in this respect. If this is not so, as defined in (8b), the eventuality in question has at least some subpart that does not show the relevant property, and so the eventuality is not internally homogeneous, but rather 'dynamic'.

(8) For a predicate P and a unit of time t:

a. P is stative iff: $\forall t[P(t) \rightarrow \forall t'[t' \sqsubseteq t \rightarrow P(t')]]$ 'total' divisibility

b. P is eventive iff: $\forall t[P(t) \rightarrow \exists t'[t' \sqsubseteq t \;\&\; \neg P(t')]]$ 'non-total' divisibility

The notions of total and non-total divisibility defined in (8) appear to stand a good chance of characterizing stative and eventive predicates respectively, particularly the challenging distinction between states and activities. The accomplishments and achievements are 'telic',

meaning they have a logical endpoint beyond which the event cannot progress (the point where the circle is complete in (1) or the point when the top is reached in (3)). But activities are 'atelic'. There is no logical end to drawing as such. What all the non-stative eventualities seem to have in common, though, is that they are comprised of certain 'atoms' of change that in turn do not have subparts that meet the predicate description. For example, *dance* is an activity predicate, but arguably consists of individual steps that are not themselves dances. In this sense, any dancing event has subparts that are not dancing events, while there is arguably no subpart of a seeing event (4) that is not also a seeing event.

On closer inspection, though, this characterization of the state/event distinction makes incorrect predictions for pairs of stative and eventive predicates that are judged synonymous such as those in (9)-(11) as well as for the progressive, discussed below. The pairs in (9)-(11) have an eventive predicate in the a-examples and a stative predicate in the b-examples. We can say *The plane was flying*, for example, but not **The plane was being in flight.* Yet, for any specified duration (*an hour* below), if the plane flew for that duration then necessarily the plane was in flight for that duration, and vice versa. That is, the a- and b-examples below are judged synonymous.

(9) a. The plane flew for an hour. [eventive]

b. The plane was in flight for an hour. [stative]

(10) a. John guarded the safe for an hour. [eventive]

b. John was on guard for an hour. [stative]

(11) a. John slept for an hour. [eventive]

b. John was asleep for an hour. [stative]

The characterization of the state/event distinction in (8) predicts such pairs to be contradictory, though they seem instead to be mutually entailing. In connection with the examples in (9), according to (8b), (9a) asserts that there are subparts of the hour-long event this sentence describes that are not events of the plane flying (12a). Example (9b), on the other hand asserts according to (8a) that there are no subparts of the eventuality in question in which the plane is not in flight (12b). These two sentences together assert that there are periods during the hour long flight at which *The plane flew* is false but at which nonetheless *the plane was in flight* is true (12c). This contradicts the intuition that *The plane was in flight* entails *The plane flew*. The definitions in (8) therefore predict the example pairs in (9)-(11) to be contradictory, when in fact they are mutually entailing.

(12) a. The plan flew for an hour.

$\exists t$ an hour(t) & fly(the-plane, t) & $\exists t'[t' \sqsubseteq t \rightarrow \neg$[fly(the-plane, t')]]

b. The plane was in flight for an hour.

$\exists t$ an hour(t) & be-in-flight(the-plane, t) & $\forall t'[t' \sqsubseteq t \rightarrow$ [be-in-flight(the-plane, t')]].

c. If the plane flew and was in flight for same hour t, then:

$\exists t' \sqsubseteq t$ [be-in-flight(the-plane, t') & $\neg$fly(the-plane, t')]

These considerations raise the question: what is the relation between an event of flying and a state of being in flight, by virtue of which all that flies is in flight and vice versa? The same question arises in connection with the progressive, where, I claim, the answer is easier

to see. As mentioned above, progressive predicates are stative while their non-progressive counterparts are eventive (as evidenced by the fact that they can be put in the progressive).

Standard contemporary analyses of the progressive exemplify various versions of the 'subpart' analysis of the progressive, which asserts that the progressive predicate describes a subpart of an event that meets the underlying verb description in some possible world (Dowty 1979, Mittwoch 1988, Lascarides 1991, Krifka 1992, Landman 1992, Portner 1998, Cipria and Roberts 2000, Deo 2009, Hallman 2009). Krifka (1992) puts this most transparently in his definition in (13), which says that a progressive predicate PROG(P) describes an event e' as being a subpart of a P-eventuality e. This definition abstracts away from modality in progressive constructions, to which I return below.

(13) Krifka (1992)

$[\![\text{PROG}(P)]\!] = \lambda e' \exists e[P(e) \ \& \ e' \sqsubseteq e]$

According to (13), a progressive predicate like *be ascending* describes a subpart of a larger ascending event, and—as the pervasive intuition goes—puts the listener 'inside' this larger event. But by virtue of this, it makes progressive predicates event descriptions, which conflicts with the observation that they pattern syntactically with stative predicates. They are event descriptions by virtue of describing subparts of events, since these subparts are themselves events. Consider the relation of *be ascending* to *ascend* from this perspective illustrated in Figure 1 below. An *ascend* event is any event in which the subject denotation has a higher altitude at the end of the event than it had at the beginning, spelled out in (14a), where *first(e)* and *last(e)* denote the first and last time points in e respectively, and where

the predicate *altitude* maps and thing and a time to a degree of vertical displacement from a deictic point of reference. On the subpart analysis in (13), the progressive *be ascending* describes a subpart of such an event, spelled out in (14b).

(14) a. The rocket ascended.

λe [altitude(the-rocket, last(e)) > altitude(the-rocket, first(e))]

b. The rocket was ascending.

$\lambda e' \exists e$ [altitude(the-rocket, last(e)) > altitude(the-rocket, first(e)) & $e' \sqsubseteq e$]

As Figure 1 illustrates, any 'slice' of an *ascend* event has the *ascend* property—the rocket is higher at the end than at the begining. On the subpart analysis, then, *ascend* applies to all the aspectual objects that *be ascending* applies to, meaning that *be ascending* should show the same aspectual behavior as *ascend*, which is eventive. The fact that *be ascending* is in fact stative calls for an explanation.

The problem here is similar to the problem seen in the examples (9)-(11). We know that the verb underlying the progressive describes an event, while the progressive derivative describes a state. The question again is: What is the relation of the *be ascending* state to the *ascend* event by virtue of which we know that *be ascending* holds during an *ascend* event?

The predicate *ascend* requires the subject denotation to have a greater altitude at the end of the event it describes than at the beginning. Since the rocket cannot have a higher altitude at any moment than it has at that same moment, the event in question must span at least two distinct moments. That is, *ascend* holds only at non-trivial intervals. One criterion that might systematically distinguish progressive predicates from their eventive bases is

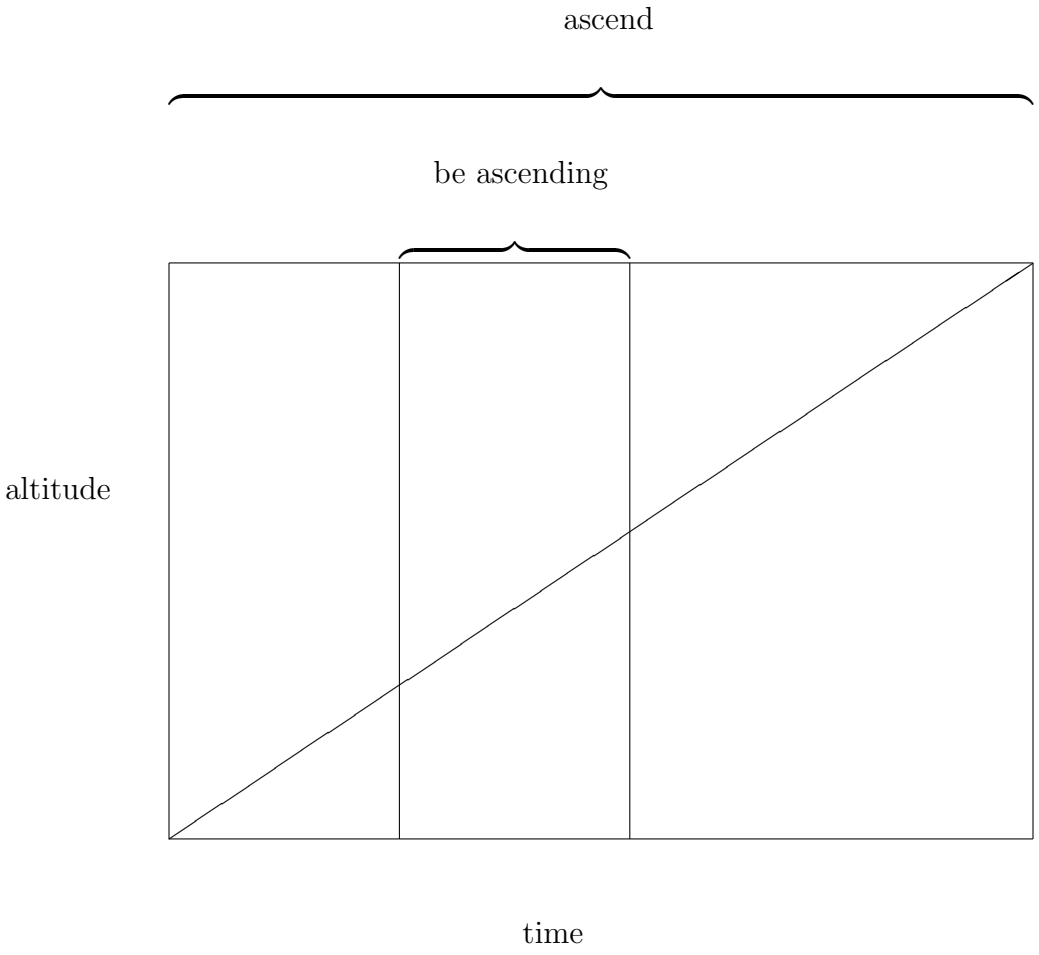

Figure 1

that progressive predicates hold at moments of time rather than intervals, as Bennett and Partee (1978) and Mittwoch (1988) propose.[1] This ensures that the aspectual arguments of progressive predicates and their underlying verb phrases do not fully overlap; the progressive applies to some eventualities that the underlying verb phrase does not, namely those that hold only at individual moments in the underlying event.

The notion that stative predicates may hold at moments while eventive predicates may not is an old idea that represents one way of construing the divisibility contrast in (8).[2] In

[1]Mittwoch calls this the 'nuclear progressive' and allows for other uses that are interval descriptions.

[2]Bach (1986, p. 588), for example, says "States *per se* do not require change. So let us say that events and

Figure 1, there is no slice of the *ascend* event that is not also an *ascend* event except for the individual moments in the interval the event spans. At these moments, *ascend* does not hold, since *ascend* requires at least two distinct moments to manifest itself. The individual moments, then, are the values for t' that validate the formula in (8b) and make *ascend* non-totally divisible. From this perspective, what distinguishes progressive predicates from their eventive derivational sources is that progressive predicate *may* hold of the individual moments in the event that the underlying verb phrase describes, so that they satisfy total divisibility as defined in (8a). Progressive predicates are then predicted to be stative, since they satisfy the total divisibility requirement.

However, the notion that a progressive predicate merely *may* hold at a moment does not rule out the situation diagrammed in Figure 1. There, the predicate *be ascending* holds of an eventuality which is an *ascend* event, since it consists in change in altitude. If *be ascending* can apply to an aspectual object to which *ascend* may also apply, then there is no inherent semantic incompatibility in double progressive constructions like (6b) from the perspective of the subpart analysis of the progressive illustrated in (13). On this view, (6b) should describe an eventuality which is a subpart of a subpart of a potential drawing a circle event.

Suppose, though, that progressive predicates hold *only* at moments of time. Then the subpart analysis itself excludes progressives from occurring in the progressive as in (6b).

processes have the property of temporality, states do not... Perhaps it is only states that can be profitably thought of as properties of moments—that is, instants—of time." In a similar vein, ter Meulen (1983, p. 181) says "There is no conceptual requirement on the duration of states... The important conceptual, and hence semantically relevant property of states is that they do not capture any changes or any movement in the world."

The formula in (15) claims that the progressive operator PROG applies to a predicate P and 'feeds' it an interval argument i (a set of moments), while the derivative describes a moment t in that interval.

(15) $\quad [\![\text{PROG}(P)]\!] = \lambda t \exists i[P(i)\ \&\ t \in i]$

If P is itself a moment description, such as a progressive predicate, then this moment description will be fed an interval in the progressive, which is an impossible argument for the moment description. It is an impossible argument because moments and intervals are different types of things, which is reflected in the semantic type of the predicates that describe them. Inserting a moment description into the P slot in (15) results in a type mismatch, since as a progressive predicate, P (for example *be ascending*), seeks a moment argument, while the progressive morpheme provides it instead with a set of moments. An interval consists of what moments are, and cannot function in the same capacity as a moment.

This reasoning leads to the conclusion that progressive predicates are moment descriptions, and this is what excludes them from the progressive. But stative predicates in general are excluded from the progressive. Consequently, if progressives are blocked from the progressive because they are moment descriptions, and if the impossibility of putting a progressive predicate in the progressive is just a subcase of the impossibility of putting stative predicates in general in the progressive, then the defining feature of stative predicates in general is that they are moment descriptions. This conclusion also resolves the conundrum surrounding the examples in (9)-(11). If *be in flight* can hold at an interval at which *fly* also holds, why is it stative while *fly* is eventive? Here too, the answer is that *be in flight* holds at moments

while *fly* holds only at intervals. This analysis therefore ensures that the stative predicates in (9)-(11) differ from their eventive counterparts in the way they do, and specifically in just the same way the corresponding progressives do.[3]

On this view, some predicates hold only at moments (call them 'stative'), others hold only at intervals (call them 'eventive'). These differ in logical degree order. Moments have no internal structure; they are logically zero-order, meaning they themselves have no argument structure; they have zero semantic complexity.[4] Stative predicates are descriptions of zero-order elements, which makes them first-order predicates. Intervals, on the other hand, are sets of moments, and like other sets, can be construed as functions from moments to truth values. This means that intervals are themselves first-order elements. Eventive predicates, then, are descriptions of first-order elements, which makes them in turn second-order. By this proposal, stative predicates are first order and must combine with a zero-order aspectual argument. They therefore do not occur in the progressive because the progressive predicates them of a first order argument (an interval), resulting in a type mismatch.[5]

[3]This conclusion entails a quantificational analysis of duration adverbials like *for an hour* in sentences like *The plane was in flight for an hour.* The adverbial here asserts that the underlying stative predicate holds at every moment during the hour long period. See Dowty (1979) and Moltmann (1991) for analyses of *for*-phrases as part quantifiers ranging over parts of intervals.

[4]I therefore do not treat moments as 'trivial' intervals, that is, intervals whose first and last moment is the same, but rather as the atomic entities of which intervals consist.

[5]This proposal maintains that a sentence like *Mary saw the star* describes a (past) moment in time. This sentence does not itself assert or even suggest that she saw the star for only that moment, or that that would even be possible; the sentence may be true of previous and subsequent moments as well. I expand on this issue in section 3. I also emphasize that although the event semantic literature sometimes makes reference to 'punctual' or 'instantaneous' events (e.g. *flash*, *turn on*), there can be no such thing on this analysis. An

Since the progressive famously does not entail the completion of anything falling under the underlying event description (often referred to as the 'imperfective paradox'), it is necessary to incorporate modality into this picture. To this end, I characterize a state as a world at a moment $\langle t, w\rangle$, so that a stative predicate like *be intelligent* relates an individual to a moment-world pair, illustrated in (16a). Since an interval is a sequence (an ordered set) of moments, we can characterize an event as a sequence of moment-world pairs, i.e. a sequence of states. Seen this way, an eventive predicate like *dance* relates an individual to a sequence of states, illustrated in (16b).

(16) a. $[\![\text{Mary is intelligent}]\!] = \text{intelligent}(\mathbf{m}, \langle t, w\rangle)$

b. $[\![\text{Mary dances}]\!] = \text{dance}(\mathbf{m}, \left\{ \begin{array}{c} \langle t_1, w\rangle \\ \langle t_2, w\rangle \\ \langle t_3, w\rangle \\ \langle t_4, w\rangle \\ \vdots \end{array} \right\})$

The ingredients to a model of aspect compatible with these claims include at least those listed in (17). T is the set of moments (the timeline), W the set of worlds, I the set of intervals (the powerset, i.e. set of subsets of the timeline), S the set of states (pairs of moments and worlds), E the set of events (subsets of S), and Ω the set of all eventualities, i.e., the states and events together. The set Ω is required because states and events are compatible with some of the same contexts, for example the past and future tenses, described in more detail below. The Davidsonian variables s and e in this context stand for moment-world pairs

event, however short, cannot 'span' an instant.

and sets of moment-world pairs respectively. The variable ω stands for any eventuality, i.e., either a state or event.

(17)

Abbreviation	Defined As	Variable Symbol
T	the set of moments	t
W	the set of worlds	w
I	$\wp(T)$	i
S	$T \times W$	s
E	$\wp(S)$	e
Ω	$S \cup E$	ω

In the discussion below, I also make use of the functions f_{time} and f_{world}, which map a state to its time and world index respectively, as defined in (18).

(18) a. $f_{\text{time}}\ [S \to T] \quad : \forall \langle t, w \rangle \ \ f_{\text{time}}(\langle t, w \rangle) = t$

b. $f_{\text{world}}\ [S \to W] \quad : \forall \langle t, w \rangle \ \ f_{\text{world}}(\langle t, w \rangle) = w$

I assume that the present tense has the effect of identifying the time of a stative main predicate with the time of the 'evaluation state', that is, the world and time with respect to which the sentence is evaluated, which is the utterance time by default (19).[6]

[6]By 'utterance time' I do not mean literally 'the time during which the utterance is made', since that is necessarily an interval. I assume that the moment representing the utterance time (the time index of s' in the definition in (19)) is a moment in the temporal proximity of, normally included in, the interval over which the utterance spans, whose exact temporal coordinate is vague and subject to pragmatic qualifications.

(19) $[\![\text{PRES}]\!]^{s'} = \lambda P \exists s\ [P(s)\ \&\ f_{\text{time}}(s) = f_{\text{time}}(s')]$

The non-finite base sentence *Mary be intelligent*, then, has the interpretation in (20a) and its present tense derivative the interpretation in (20b).

(20) a. $[\![\text{Mary be intelligent}]\!] = \lambda s\ [\text{intelligent}(\mathbf{m}, s)]$

b. $[\![\text{Mary is intelligent}]\!]^{s'} = \exists s\ [\text{intelligent}(\mathbf{m}, s)\ \&\ f_{\text{time}}(s) = f_{\text{time}}(s')]$

In these terms, the core progressive in (15) is redefined in (21a). The non-finite base sentence *Mary cross the street* is an event description, as shown in (21b), while its progressive derivative is a state description as in (21c). Its present tense derivative is spelled out in (21d).

(21) a. $[\![\text{PROG}]\!] = \lambda P \lambda s \exists e[P(e)\ \&\ s \in e]$

b. $[\![\text{Mary cross the street}]\!] = \lambda e\ \text{cross}(\mathbf{m}, \text{the-street}, e)$

c. $[\![\text{Mary be crossing the street}]\!] = \lambda s \exists e\ \text{cross}(\mathbf{m}, \text{the-street}, e)\ \&\ s \in e$

d. $[\![\text{Mary is crossing the street}]\!]^{s'} = \exists s \exists e\ \text{cross}(\mathbf{m}, \text{the-street}, e)\ \&\ s \in e\ \&\ f_{\text{time}}(s) = f_{\text{time}}(s')$

The present tense on this account is typed to combine with a stative predicate, which it feeds a state argument. This ensures that eventive predicates cannot occur in the simple present tense without the intervention of the stativizing progressive morphology or other stativizing semantic operators, such as a hidden quantificational adverb or 'generic operator' that derives the habitual reading of sentences like *Mary dances*, meaning she dances regularly or professionally, or the generic reading of *Mary eats meat*, meaning she is not predisposed to

not eat meat (Carlson 1977, 1989, Heim 1982, Krifka et al. 1995 and many others; Condoravdi 2002 and Stowell 2007 mention explicitly that generic predicates are stative). This analysis therefore has the exclusion of stative predicates from the progressive and the exclusion of eventive predicates from the present tense as natural outcomes of the combinatoric type of stative and eventive predicates, the present tense and the progressive.

Note, furthermore, that nothing in this proposal requires an event construed as a sequence of states to 'stay' in one world. As a result, a predicate like *cross the street* might relate an individual *Mary* to a sequence of states that begins in a world w_1 but completes in w_2, as illustrated in (22).

(22) $[\![\text{Mary cross the street}]\!] = \text{cross}(\mathbf{m}, \text{the-street}, \left\{ \begin{array}{c} \langle t_1, w_1 \rangle \\ \langle t_2, w_1 \rangle \\ \langle t_3, w_1 \rangle \\ \langle t_4, w_2 \rangle \\ \langle t_5, w_2 \rangle \\ \langle t_6, w_2 \rangle \\ \vdots \end{array} \right\})$

This means that predicating the progressive description in (21c) of a state in the past does not entail that the crossing the street event will continue in the world of that state. This feature of this analysis derives the 'imperfective paradox'—the fact that progressive sentences do not entail the culmination of the underlying verb phrase (in the valuation world). From this perspective, the non-completiveness of the progressive is not a contribution of the progressive morphology but is inherent in the underlying verb phrase denotation. On the other hand, it

is clear that if we say *Mary crossed the street*, we assert that the crossing *does* culminate in the valuation world. If this analysis of the imperfective paradox is on the right track, then it is not the case that the progressive removes a completiveness entailment, but rather that non-progressive contexts introduce one.

To capture both the completiveness of simple past assertions like *Mary crossed the street* as well as the fact that tense operators accept both stative and eventive predicates, I first define the functions 'before' and 'after' as in (23). The function f_{before} maps a state s to the set of states whose time index temporally precedes the time index of s and whose world index is identical to the world index of s. That is, f_{before} maps a state to the set of all prior states in the same world. The function f_{after} is defined analogously.

(23) a. $f_{\text{before}}\ [S \rightarrow E]\ :\ \forall s \in S\ f_{\text{before}}(s) = \{s' : f_{\text{world}}(s') = f_{\text{world}}(s)\ \&\ f_{\text{time}}(s') \prec f_{\text{time}}(s)\}$

b. $f_{\text{after}}\ [S \rightarrow E]\ :\ \forall s \in S\ f_{\text{after}}(s) = \{s' : f_{\text{world}}(s') = f_{\text{world}}(s')\ \&\ f_{\text{time}}(s) \prec f_{\text{time}}(s')\}$

I then define past tense in terms of the function f_{past} in (24a), that maps a state s to the union of $f_{\text{before}}(s)$ and $\wp(f_{\text{before}}(s))$, the set of all subsets of $f_{\text{before}}(s)$. That is, f_{past} maps a state to a set including all the states and events prior to s in the same world. Again, f_{future} is defined analogously in (24b).

(24) a. $f_{\text{past}}\ [S \rightarrow \Omega]\ :\ \forall s \in S\ f_{\text{past}}(s) = f_{\text{before}}(s) \cup \wp(f_{\text{before}}(s))$

b. $f_{\text{future}}\ [S \rightarrow \Omega]\ :\ \forall s \in S\ f_{\text{future}}(s) = f_{\text{after}}(s) \cup \wp(f_{\text{after}}(s))$

I now define the past tense morpheme as an operator that combines with a predicate and asserts that the predicate holds of an eventuality in the past of a reference state (the utterance state by default). That is, it asserts that the predicate's eventuality argument is in the set $f_{\text{past}}(s)$, for a reference state s. The future tense puts the eventuality in the future of s.

(25) a. $[\![\text{PAST}]\!]^s = \lambda P \exists \omega\ P(\omega)\ \&\ \omega \in f_{\text{past}}(s)$

b. $[\![\text{FUT}]\!]^s = \lambda P \exists \omega\ P(\omega)\ \&\ \omega \in f_{\text{future}}(s)$

Based on these components, the denotation of *Mary was crossing the street* is shown in (26a) and that of *Mary crossed the street* is shown in (26b).

(26) a. $[\![\text{Mary was crossing the street}]\!]^{s'} = \exists s \exists e\ \text{cross}(\mathbf{m}, \text{the-street}, e)\ \&\ s \in e\ \&\ s \in f_{\text{past}}(s')$

b. $[\![\text{Mary crossed the street}]\!]^{s'} = \exists e\ \text{cross}(\mathbf{m}, \text{the-street}, e)\ \&\ e \in f_{\text{past}}(s')$

These definitions guarantee that if Mary crossed the street, the entire crossing took place in the same world as the evaluation state s' in (26b), by virtue of the definition of past tense. The past progressive assertion in (26a) only asserts that the state that the progressive predicate itself holds of is in the same world as the reference state s', and therefore does not commit to the completion of the crossing event e in that same world.

The analysis fleshed out above derives the fact that progressive predicates are stative (because they hold at moments), and also accommodates both the fact that progressive predicates do not commit to developments after the state they describe in the 'reference

world' (because an event may by definition 'span' distinct worlds) as well as the fact that past tense eventive predicates *do* commit to the completion of the event in the reference world (because the past tense puts the eventuality argument in the past of the reference world). Like other analyses, the analysis presented here derives the imperfective paradox, but goes beyond other analyses in also deriving the stativity of the progressive as part and parcel of its meaning. While other analyses have little to say about the origin of the stativity of progressive predicates, the analysis presented here makes this feature a consequence of the partitive meaning of the progressive; progressive predicates describe a momentary subpart of the underlying event, and therefore share the distribution of other moment predicates. This distribution is characterized by a variety of conditions on the occurrence of stative predicates, two of which were discussed above. Progressive predicates are like other stative predicates in being licit in the present tense in English, which does not admit eventive predicates. This falls out in the analysis presented here because the present tense equates the eventuality argument of its predicate complement with the reference state, so the predicate's eventuality argument must also be a state. Progressive predicates are also like other stative predicates in failing to occur in the progressive (6b). This falls out in the analysis presented here because the progressive 'places' the moment it describes in an interval that the underlying verb phrase describes. Consequently, the underlying verb phrase may not itself be a moment description.

I end this section by discussing two additional contexts that interact with the state/event distinction, in order to illustrate how the analysis proposed here can be extended to other phenomena. Both cases illustrate that contexts for stative predicates can naturally be characterized as contexts for descriptions of moment-world pairs.

The first case concerns sentences like those in (27), discussed by Ogihara (1989, 1996), Katz (2001) and Abusch (2004). Verbs like *believe* combine with a stative infinitival complement such as progressive *be raining*, but not with an eventive infinitival complement like *rain*, as illustrated in (27a). Verbs like *expect*, on the other hand, combine with both stative and eventive infinitival complements, as illustrated in (27b).[7]

(27) a. Fritz believes it to *rain / be raining.

b. Fritz expects it to rain / be raining.

The literature cited above agrees that the ungrammaticality of an eventive infinitival complement for *believe* goes hand in hand with the fact that a stative infinitival complement is interpreted as simultaneous with the matrix reference time (the utterance time in (27a)), so that on some level the ungrammaticality of **Fritz believes it to rain* is the same fact as the ungrammaticality of **It rains*. If Fritz believes it to be raining, then according to Fritz's beliefs, it is raining now, at the time he holds this belief. In terms of the present proposal, if *believe* identifies the embedded eventuality time with the time of believing, and belief is itself a state that holds at a moment, then an eventive predicate like *rain* cannot occur with *believe* because the time span of the raining cannot be identified with the moment of belief, since the raining spans an interval.

On this view, the meaning of *believe* as it is used in (27a) is roughly that shown in (28). It is interpreted with respect to a modal base *MB*, which, in combination with a state

[7] Abusch identifies two classes of verbs based on the pattern in (27). Verbs that behave like *believe* include *assert*, *claim*, *confess*, *know*, *report*, *say* and *think*. Verbs that behave like *expect* include *anticipate*, *forecast*, *intend*, *mean*, *plan*, *predict* and *project*.

argument, refers to a set containing all the worlds compatible with the beliefs of the subject denotation (in this case Fritz) in that state. It asserts for a predicate P (*be raining* but not *rain*) and a state s (the 'utterance' state in which the belief holds) that in every world in *MB(s)*, that is, compatible with Fritz's beliefs in s, P holds in that world at the time of s. P cannot be an eventive predicate like *rain* because the time of s is a moment and eventive *rain* cannot hold at a moment.

(28) $\quad [\![\text{believe}_{\text{MB}}]\!] = \lambda P \lambda s \forall w[w \in MB(s) \rightarrow P(\langle f_{\text{time}}(s), w\rangle)]$

The fact that unlike *believe*, *expect* can take an eventive infinitival complement (as well as a stative one), goes hand in hand with the fact that *expect* has a future orientation: it asserts that the event or state described by its infinitival complement holds in the future in worlds compatible with what Fritz expects at the utterance time. With both an eventive and stative infinitival complement, *expect* puts the event or state so described in the future. Because *expect* is compatible with both eventive and stative complements, the definition of the use of *expect* illustrated in (29) makes use of the variable symbol ω, ranging over events and states. This time, *MB(s)* denotes the set of worlds compatible with Fritz's expectations in s. As defined in (29), *expect* asserts of a (stative or eventive) predicate P and a reference state s (the time and world of the expectation) that for all worlds compatible with what Fritz expects in s, there is a P-eventuality ω in the future of s with respect to the time of s ('now' in (27b)).

(29) $\quad [\![\text{expect}_{\text{MB}}]\!] = \lambda P \lambda s \forall w[w \in MB(s) \rightarrow \exists \omega P(\omega)\ \&\ \omega \in f_{\text{future}}(\langle f_{\text{time}}(s), w\rangle)]$

This definition captures the fact that whether the expectation is about a state (*be raining*) or an event (*rain*), the state or event in question holds in the future (in all Fritz's 'expectation worlds'). Since the eventuality described by the underlying infinitive predicate need not hold at the time of the expecation itself, it may be an event, unlike in the case of *believe*, where the identification of the time of the belief (a moment, since *believe* is itself a stative verb) with the time of the infinitival complement, requires the latter to also be a moment, which has the effect of limiting the infinitival complement of *believe* to stative predicates.

A similar temporal configuration distinguishes the epistemic from the root reading of modal verbs, which I describe here as a final illustration of the analysis of the state/event distinction proposed here. The examples in (30), from Condoravdi (2002), illustrate a semantic ambiguity that *might* shares with other modal verbs (Hoffmann 1966, McCawley 1971, Kratzer 1981, Stowell 2004).

(30) a. John might be here. [Epistemic]

b. John might run. [Metaphysical]

As Condoravdi explains, when we say (30a), we are presupposing that it is actually settled in the valuation world whether or not John is here, we just don't know which way it is settled (we don't see him). The uncertainty in this case is *epistemic*; the knowledge of the speaker does not extend to *how* the issue of John's being here is settled, though the speaker knows that it is settled one way or the other. This is in contrast to (30b), in which the uncertainty is about how things will develop in the future. It is not settled at the utterance time whether John runs or not. The uncertainty here is not just in the speaker's epistemic

state, the uncertainty resides in the world itself. Condoravdi (2002) refers to this kind of uncertainty as 'metaphysical'. Settling an issue eliminates metaphysical uncertainty, but not necessarily epistemic uncertainty, since we may remain unsure how it is settled, as in the case of (30a).

As the examples in (30) illustrate, the kind of uncertainty that *might* expresses is restricted by the aspectual type of the underlying predicate. Only the stative predicate in (30a) is compatible with the epistemic reading of the modal. The eventive predicate in (30b) triggers the metaphysical reading. Condoravdi derives this interaction in the following way. She defines *might* as in (31a) based on the definition of the temporal AT relation in (31b) (p. 70-71). In (31a), MB represents a modal base (again a set of worlds) and $[t, \_)$ represents the interval beginning at t and extending infinitely forward in time. In (31b), $\subseteq$ is the subset relation and $\circ$ is the overlap relation, and τ is the temporal trace of an eventuality in a world.

(31) a. $[\![\text{might}_{\text{MB}}]\!] = \lambda P \lambda w \lambda t \exists w'[w' \in MB(w,t) \ \&\ \text{AT}([t, \_), w', P)]$

b. $$\text{AT}(t,w,P) = \begin{cases} \exists e[P(w)(e) \ \&\ \tau(e,w) \subseteq t] & \text{if } P \text{ is eventive} \\ \exists e[P(w)(e) \ \&\ \tau(e,w) \circ t] & \text{if } P \text{ is stative} \end{cases}$$

In connection with the definition of the present tense in (32), Condoravdi attributes to the examples in (30) the logical forms in (33a) and (34a) respectively, and the denotations in the respective b-examples.

(32) $[\![\text{pres}]\!] = \lambda P \lambda w[\text{AT}(now, w, P)]$

(33) a. $\text{pres}(\text{might}_{MB}(\text{he be here}))$

b. $\lambda w \exists w'[w' \in MB(w, now) \ \&\ \exists e[[\text{he be here}](w')(e) \ \&\ \tau(e,w') \circ [now, \_)]]]$

(34) a. pres(might$_{MB}$(he run))

b. $\lambda w \exists w'[w' \in MB(w, now)$ & $\exists e[[\text{he run}](w')(e)$ & $\tau(e, w') \subseteq [now, \_)]]]$

According to (33b), *He might be here* says that he is here in a world in the modal base and his being here temporally overlaps in that world with an interval that begins now (at the utterance time) and extends indefinitely into the future. The denotation for *He might run* in (34b) says that he runs in a world in the modal base and his running is temporally included in an interval that begins now and extends indefinitely into the future. The running in (34b) therefore begins in the future, it cannot have already started in the past, while the being here in (33b) might have already started before now. This difference in temporal construal arises because of the different interaction of stative and eventive predicates with the AT predicate defined in (31b), which appears in the definition of *might* in (31a).

On this analysis, the modal is uniform in meaning. There is no lexical semantic difference between the epistemic and metaphysical interpretations. The two interpretations are associated with different modal bases. On the epistemic interpretation, the modal base consists of epistemic alternatives to the actual world, that is, worlds that are compatible with what the speaker knows to be the case in the actual world. On the metaphysical interpretation, the modal base consists of metaphysical alternatives to the actual world, that is, worlds that are compatible with how unsettled things get settled in the future. The modal base cannot be metaphysical if the main predicate holds at the utterance time, that is, if it overlaps with *now*. This is because the way the world is at the utterance time is settled at the utterance time. Since settling an issue eliminates metaphysical alternatives to it, there can be no metaphysical alternatives to a world *at* a time, but only in the future with respect

to that time. But we may still entertain epistemic alternatives to the way the world is at a time, because the uncertainty here pertains to the speaker's knowledge of how things are settled, not to whether or not they are settled. Consequently, the stative predicate *be here* in (30a), which (33b) asserts overlaps with the valuation time (now), is incompatible with a metaphysical modal base for *might*, since whether he is here right now is necessarily settled. Consequently, only an epistemic reading is available in (30a).

Recall that the future of a state defined in (24b) does not include the present of that state. Consequently, the tools developed in this study so far do not provide a way of capturing Condoravdi's uniform meaning for *might*, where it puts an eventuality either in its future (where it is compatible with a metaphysical modal base) or its present (where it is only compatible with an epistemic modal base). To accommodate this uniformity, I define the notion of the 'inclusive future' of a state s in (35) as a set of states and events that are either simultaneous with s (though no event can have this property) or after it. Specifically, the function $f_{\text{fut-incl}}$ maps a state s to a set that includes s itself, all the states after s, and all the events consisting entirely of states after s (all in the world of s due to the definition of *after* in (23b).

(35) $\quad f_{\text{fut-incl}}\ [S \rightarrow \Omega]\ :\ \forall s \in S\ f_{\text{fut-incl}}(s) = \{s\} \cup f_{\text{after}}(s) \cup \wp(f_{\text{after}}(s))$

Drawing on (35), the definition in (36) for *might* expresses the Condoravdian insight that the modal base of *might* is connected to where the underlying eventuality is temporally situated with respect to the time of the modal attitude, in combination with the view that stative predicates are moment descriptions. *Might* combines with either a stative or eventive

predicate P, a reference state s (at which time the possibility expressed by *might P* holds), and a state or event ω, and asserts that ω (John running or John being here) is the case in a world included in the modal base at a time included in the inclusive future of s. If the underlying predicate is stative *John be here*, that state may hold at the time of s itself, but in another world w, in which case the modal base must be epistemic by Condoravdi's logic. If it is eventive *John run*, then that event cannot hold at the time of s, which is a moment, and so must hold after s, where it is compatible with a metaphysical modal base.

(36) $\quad [\![\text{might}_{\text{MB}}]\!] = \lambda P \lambda s \lambda \omega \exists w[w \in MB(s)\ \&\ P(\omega)\ \&\ \omega \in f_{\text{fut-incl}}(\langle f_{\text{time}}(s), w\rangle)]$

The discussion above is intended to demonstrate that the view that stative predicates hold only at moments, motivated in the first instance as an explanation for why progressive predicates are stative, is also compatible with insights on the interaction of the state/event distinction with other semantic phenomena. I turn below to some criticisms that have been leveled in the philosophy literature against any role for moments in natural language semantics. These criticisms, I claim, do not apply to the analysis of stativity fleshed out above.

3 In defense of moments

Moments of time have not enjoyed an unequivocally positive reception in the literature on tense and aspect. Some of this literature is concerned not so much with arguing against the relevance of moments but with demonstrating the importance of intervals, as a reaction to most work in formal semantics through the 1960s, in which moments or vaguely defined

'times' were the only currency of temporal analysis. Building on Reichenbach (1947), works by Montague (1973), Scott (1970) and others attribute a moment index to untensed sentences, that tense operators order with respect to the utterance time. Works by Bennett and Partee (1978), Dowty (1979), Kamp and Reyle (1993) and many others demonstrate the clear necessity for intervals in the analysis of temporal and aspectual phenomena, a view that the present work of course endorses.

But Hamblin (1971) goes so far as to claim that intervals are not sets of moments but are themselves the atomic temporal units in language, with moments definable derivatively in relation to the edges of intervals. The present work argues against this view. It claims that moments play an important role in temporal and aspectual phenomena, as do intervals, and that moments are the atomic units that intervals consist of. I claim that precisely this difference in logical complexity is the critical distinction between states and events that governs differences in distribution between stative and eventive predicates. The difference in degree order between states and events corresponds to a difference in degree order between stative and eventive predicates that is the source of the differences in their distribution.

Arguments against the role of moments in language in Hamblin's and other works have a decidedly psychological flavour. Hamblin says, for example:

> Logical positivists, owing something to Mach and to Carnap's early *Logischer Aufbau*, have often assumed that the atoms of our experience have a form like "Red — here — now" or perhaps "Red(x,y,z,t)", and that the whole of what we meaningfully say can be represented as a logical function, albeit very complicated, of statements of this form... But, whatever we think about the ultimate thesis,

> there is one incongruity at its very base, namely the presence in the atoms of coordinates of position and time of an apparently purely Newtonian or Kantian nature, unsupported by any attempt to give a phenomenal account of them... It can hardly be said that we observe qualities like redness to exist at Euclidean space-time points. In fact, it is not clear what such a contention could mean. (Hamblin 1971, p. 127)

According to Hamblin, the idea that a sentence like *Mary's hat is red* holds at a moment of time implies that our elementary experiences are extentionless and instantaneous. Since we do not perceive qualities like redness at dimensionless time points, though, it cannot be the case that *Mary's hat is red* is true at a dimensionless time point. This argument contains a questionable tacit assumption, though, namely that a sentence like *Mary's hat is red* describes the world co-synchronously with our perception that the hat is red, that is, that a sentence is necessarily true or false at the temporal coordinates at which we perceive the sentence to be true or false. The idea that there can be no temporally dimensionless *experiences* strikes me as sound. Aside from the fact that the physical processes underlying perception are themselves processes, it is arguably the case that all qualities only manifest themselves over intervals, as Whitehead argues:

> Suppose we keep to the physical idea of energy: then each primordial element will be an organised system of vibratory streaming of energy. Accordingly there will be a definite period associated with each element; and within that period the stream-system will sway from one stationary maximum to another stationary maximum... This system, forming the primordial element, is nothing at any

> instant. It requires its whole period in which to manifest itself. In an analogous way, a note of music is nothing at an instant, but it also requires its whole period in which to manifest itself. (Whitehead 1925, p. 37-38)

Two distinct colors, like distinct pitches, differ only in their periodicity; but nothing has periodicity at a moment. Consequently, as Whitehead and Hamblin correctly claim, we cannot tell if Mary's hat is red by limiting our *observation* of the hat's redness to a particular instant of time. As described above, however, the claim that moments have no role in linguistic semantics is based on the additional assumption that in ascertaining a sentence's truth value, we limit our observations to the way the world is at the sentence's temporal coordinate. Kamp and Reyle (1993) operate under this same assumption in arguing against a role for moments in linguistic semantics, specifically in connection with the claim that progressive predicates may hold at moments. Assuming that the time t is a moment, they write:

> Mary was writing a letter at t iff there is some letter b such that the pair $\langle Mary, b\rangle$ belongs to the extension at t of the two-place predicate *write*... What could it be about the way the world... is at the instant t that makes it true that Mary and b stand in the *write* relation at t? The fact that her pen touches the paper on which the letter is being written?... Let us consider the other two predicates we have mentioned above, *asleep* and *run*. At first glance, the notion that Mary's belonging to the extension of *asleep* at t could be assessed just on the strength of what is the case at that very moment may seem more plausible than it was for *write a letter*. But on closer inspection the case does not look to be much better.

> When someone is asleep, he is always asleep for some stretch of time. This is how we tell he is asleep, and in fact, what could it *mean* for someone to be asleep at t without being asleep at some interval... of which t is a part? (Kamp and Reyle 1993, p. 502–3)

Here, Kamp and Reyle argue that the way the world is at a particular instant does not provide us with enough information to ascertain whether a sentence like *Mary is writing a letter* is true at that instant or not. Here again, this point is correct, but only qualifies as an argument against the relevance of moments in linguistic semantics if a moment description must be assessed, as they put it, 'just on the strength of what is the case at that very moment', and is blind to what is the case at all other times. This is the same assumption that Hamblin is operating under when he says that temporally dimensionless time coordinates are incompatible with the fact that it takes time to perceive whether a sentence is true or not. These things only conflict if we are limited to examining the way the world is at a sentence's temporal coordinate in order to determine whether the sentence is true.

But the assumption that a sentence describes the world co-synchronously with our perception of its semantic value is highly problematic even in an interval or event based semantics. Consider Kamp and Reyle's analysis of the present perfect, for example (p. 570ff). According to Kamp and Reyle, the sentence in (37a) asserts that there exists a time t, a state s and an event e for which the conditions in (37b) hold, namely that t is now, t is within s (i.e., s persists into the present), and e abuts s (i.e., s starts when e ends) and e is an event of Mary meeting the president.

(37) a. Mary has met the president.

b. t=now & $t \subseteq s$ & $e \supset\subset s$ & e is an event of Mary meeting the president

Even if t is an interval, if we limit ourselves to inspecting the world at t, we will never be able to determine whether Mary has met the president or not, since the meeting took place before t. It does not even suffice to extend our observations to s, since s also does not include the meeting of the president. We must inspect all of t, s and e and check whether they stand in the configuration asserted by (37b). We cannot do this if we must evaluate (37a) only on the strength of what is the case at t.

Not just in temporal semantics, but quite generally, we do not limit ourselves to inspecting an individual to decide whether some predicate holds of it. If we did, we could never decide the truth of sentences like those in (38). We cannot tell if the predicate 'divorced' holds of Mary only by looking at Mary. We have to check whether there is someone to whom she was previously married. Similarly, inspecting Lincoln will not help us decide whether he was the 16th president in (38b); we have to identify the people who were president before him and count them. Inspecting Mary alone in (38c) will not tell us whether she has three bank accounts.

(38) a. Mary is divorced.

b. Lincoln was the 16th president of the US.

c. Mary has three bank accounts.

By the same token, construing any of these sentences as descriptions of moments does not limit us to inspecting that moment when we consider whether the sentence is true. I suspect that even Whitehead and Hamblin would not insist that (38b) holds at the interval during

which we count the other presidents, though this is what they say about *Mary's hat is red*, where they identify the temporal index of the sentence with the experience of perceiving the quality 'red'. The process of ascertaining whether the world meets a certain truth condition is not the same kind of thing as the truth condition itself. The moment coordinate of the sentence figures in the calculation of whether it is true, but does not limit our access to other moments and intervals in the course of determining the sentence's truth value, and the sentence's truth conditions may even require an instant to be related to other instants or intervals in a systematic way, as in the case of the progressive.

I address lastly another potential criticism of the present work, this time in connection with its characterization of events. The model of aspectual interpretation proposed in section 2 claims that states are moment-world pairs and that events are temporally ordered sets of states. From this perspective, events resemble a 'filmstrip' of states, each representing a discrete stage in the development of the event. Like moments, the filmstrip model has met with some disapproval in semantics and philosophy, as in the following passage in Krifka (1998):

> [Earlier work] assumed *discrete* representations of paths and times—paths are seen as a collection of points in space, time intervals are seen as sets of time points... This leads to the "filmstrip" model of change, a perspective that may seem plausible after the advent of movie cameras, but arguably is not the way how movement and change is conceptualized... We do not see a moving object as appearing in a succession of distinct locations; rather, we see it as moving continuously along a path. (Krifka 1998, p. 198)

The objection to the filmstrip model in this and other work (see for example Kamp and Reyle 1993, p. 503) is that it is not a realistic representation of the way events are *perceived*, which is continuous, but rather an analogy coincidentally facilitated by our experience with filmstrips. We do not see objects moving in a digital fashion, so a digital representation of motion or other events is inappropriate. This view again presupposes a very tight correlation between the perception of events and their representation in language. Since the event itself does not consist of discrete parts, the argument goes, the linguistic representation of the event should not either. But linguistic representations are necessarily more abstract than the perception of the represented event itself. When we tell someone that an object moved, they do not have access to our original perception. The listener establishes a discourse referent corresponding to the moving of the object but knows little more about it than that the object occupied distinct locations at distinct times during the event. The representation in this case is constructed on the basis of a linguistic description that does not convey anything on par with the speaker's original perception. I submit, then, that the idea that *linguistic* representations of events are sequences of states is not in conflict with the apparent continuity of perception.[8] I have sought in this paper to establish that the filmstrip model

[8]I say 'apparent' continuity because not all models of visual perception agree that perception is in fact continuous. It undermines Krifka's argument to some extent that if we watch a *filmstrip* of a moving object, we see it as moving continuously along a path even though in this case we actually categorically *did* see it appear in a succession of distinct locations. This suggests that the human visual system is capable of reconstructing movement where there was none, 'sewing together' a sequence of discrete states into a perception of continuous change. The illusion of continuous change in filmstrips, then, arises by virtue of this very capability of the visual system. Exactly this is the conclusion drawn by Purves et al. (1996), Crick and Koch (2003), Andrews and Purves (2005), VanRullen et al. (2005, 2006), VanRullen (2006, 2007), Rojas

has added value in semantic analysis. It derives the fact that progressive predicates are stative—something other analyses of the progressive must stipulate—and is compatible with various interactions of tense, aspect and modality.

4 Conclusion

In this paper, I have sought to formalize and substantiate the hypothesis that the characterizing feature of stative predicates is that they hold at moments of time, never at intervals. Conversely, eventive predicates hold only at intervals, never at moments. A commensurate notion of 'state' and 'event' as objects of linguistic reference is developed that depicts a state as a world at a moment and an interval as a sequence of states. A formulation of the tenses compatible with this view is also developed, as well as a formulation of the meanings of modal verbs and verbs taking infinitival complements that both illustrate the present proposal and

et al. (2006), VanRullen et al. (2008) and others on the basis of experimental evidence. They claim that visual perception is periodic, and perceived continuity of motion is a higher-level cognitive construct. This aspect of human visual perception is argued to explain the 'wagon wheel' illusion and certain visual aphasias. In the wagon wheel illusion, a rotating wheel is perceived to stop rotating because, according to Purves and others, at a certain speed, the rotation of the wheel synchronizes with the visual system's sample rate so that the wheel makes one full rotation between 'snapshots', and the visual system cannot distinguish this situation from a non-rotating wheel. If the wheel makes slightly less or slightly more than one full rotation it is perceived to be moving slowly backwards or forwards respectively. This view of the origin of the wagon wheel illusion is not universally accepted, with Kline et al. (2004) and Kline and Eagleman (2008) arguing for an alternative explanation involving an interaction of direction-sensitive motion detectors in the visual system. I am not qualified to weigh in on this controversy, and can only emphasize that the idea that human visual perception is not digital is not as foregone a conclusion as Krifka suggests.

demonstrate its cross-constructional robustness.

The main empirical return on this effort is an explanation for the stativity of the progressive, a property that is unexpected from the perspective of the standard subpart analysis. If progressive predicates hold of temporally non-trivial subparts of the underlying event, progressive predicates should be eventive, since those subparts are events. Therefore, if conventional subpart analyses of the progressive are on the right track, the subpart that the progressive describes must be trivial, i.e. temporally dimensionless. The fact that progressive predicates pattern together with stative predicates in general implies in turn that the temporal dimensionlessness of the progressive is in fact the characterizing property of stativity. The imperfective paradox (the fact that progressive predicates do not entail the completion of the underlying event) is analyzed here as the unmarked state of affairs—an event may 'span' distinct worlds. The reason why not all expressions are non-completive in this way is that the tenses 'lock' the eventuality argument of their complement into the reference world (the utterance world by default). By virtue of the fact that progressives project a state argument included in the underlying event, the remainder of the event following that state is never associated explicitly with the reference world.

Lastly, the Euclidean view advocated here of the way reference to time is grammaticalized in natural language is defended against the objection that it is psychologically unrealistic. I have endeavoured to show that the objection is based on the premise that the truth of a sentence is established solely on the strength of what can be perceived at the temporal index of that sentence. Since that premise is unrealistic on any account, it must not be correct.

The resulting theory attributes differences in the distribution of stative and eventive predicates to a difference in logical type between the two. Events consist of what states

are, so stative predicates have a lesser degree order than eventive predicates. Placing an eventive predicate in a position typed for a stative predicate or vice versa results in a type mismatch between the predicate and its syntactic context. While some contexts are flexible (the past and future tenses as defined in (25), or propositional complement verbs of the *expect* class as defined in (29) or modal verbs as exemplified by *might* as defined in (36)), other contexts, such as the present tense as defined in (19), the progressive as defined in (21a) or propositional complement verbs of the *believe* class as defined in (28), place combinatorial demands on the logical type of their argument that manifest themselves as restrictions on the distribution of stative and eventive predicates.

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