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## Two puzzles for a theory of lexical aspect: semelfactives and degree achievements

### 1 The Puzzle about Vendler Classes

Vendler 1957/1967, followed by Dowty 1979, distinguished four classes of verbs, based on empirical evidence such as different patterns of cooccurrence with various kinds of temporal modifiers. The classification is semantic, since the different verb classes are distinguished by the different properties of the events in their denotation. The four classes that Vendler distinguishes are states, such as *love*, *know* and *believe*; activities, such as *run*, *walk* and *swim*; achievements, such as *arrive*, *die*, *notice*, *realise*, and *reach*; and accomplishments, such as *read (a book)*, and *build (the house)*. I discuss the linguistic properties of these classes in detail in Rothstein (2004); the most important facts can be summarised as follows. First, states and achievements do not naturally occur in the progressive, while activities and achievements do, as illustrated in (1):

- (1) (a) #John is believing in the devil.  
(b) #John is noticing the picture .  
(c) Mary is running.  
(d) Mary is building a house.

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\* The first part of this paper is a revision of parts of chapter 8 of Rothstein 2004. The material in parts 6-8 is entirely new. The material has been presented a number of times: at the Workshop on Events in Leipzig, at IATL 20, and at colloquia at ZAS, Nanzan University, the University of Tokyo, SISSA, Tel Aviv University, and the Hebrew University of Jerusalem. I thank audiences at all these events for their comments and discussions. As usual, discussions with Fred Landman were particularly fruitful. This research was partially supported by the Israel Science Foundation Grant #951/03.

Second, achievements and accomplishments occur naturally with telic modifiers, while states and activities do not, as illustrated in (2).

- (2) (a) John believed in the devil #in half an hour/ for several years.  
 (b) Mary ran #in half an hour/for half an hour.  
 (c) John noticed the picture in half an hour/#for half an hour.  
 (d) Mary built a house in two weeks /#for two weeks.

Third, accomplishments, but not activities induce the imperfective paradox: in other words, activities occurring in the progressive consistently allow the entailment pattern illustrated in (3a), while accomplishments don't, as illustrated in (3b):

- (3) (a) John was running ENTAILS John ran.  
 (b) John was building a house DOES NOT ENTAIL John built a house.

In general, verbs which occur with *in a time* induce the imperfective paradox, and those which do not occur with *in a time* do not. (For a discussion of some of the apparent counterexamples to all these generalisations see Rothstein 2004.)

The organisation of verb classes which these tests gives us is summed up in (4), with the features [ $\pm$  occur in the progressive] and [ $\pm$ co-occur with telic modifiers] allowing us to characterise uniquely each of the four classes.

(4)

	[ $\pm$ occur in the progressive]	[ $\pm$ occur with telic modifiers]
States	–	+
Activities	+	–
Achievements	–	+
accomplishments	+	–

However, there are several questions which the above table raises. First, what about verbs which apparently don't fit into any of these classes? There are two very obvious classes which do not fit into the classification. The first is the class of semelfactive verbs, such as *kick*, *knock*, *jump*, *skip*, and *flap(its wings)*, which are homonymous with activity verbs but which denote 'single action events', as when *knock* denotes a set of events in which one's hand or an object in one's hand comes into contact with a hard surface only once. As we will see below, they apparently form a fifth kind of event and thus a fifth class of verbal predicate, and as such cause a problem for a categorisation based on two features. The second set of problematic verbs are so called degree achievements, such as *cool*, *warm* and *reddden* which appear to fit into too

many classes, since they seem to behave like achievements and like activities, and sometimes like accomplishments as well, as we will see below.

There is a second question regarding the table in (4): what is the special significance of occurring in the progressive and occurring with telic modifiers which means that these properties should characterise the verb classes? And a third issue is, what is the relationship between the table in (4) and Krifka's characterisations of verb meanings in terms of whether or not they are cumulative? In this paper, I shall discuss all of these issues. We will begin with what is special about the progressive and cooccurrence with telic modifiers as tests for verb classes, and go on to discuss the relation between these tests and Krifka's tests for cumulativity. We will then, in section 4 and 5, use the answers to these questions to approach the issue of semelfactives and their relation to the other verb classes, and in section 6 we will discuss degree achievements.

## 2. A Theory of Lexical Aspect (Rothstein 2004)

We start with the question of what the features in (4) mean. These features reflect fundamental characteristics of events. The property of appearing or not appearing in the progressive reflects whether a predicate denotes temporally extended events or (near) instantaneous events, while the property of appearing with telic modifiers, correlates in (4) with whether or not a predicate denotes an event of change. We will look at each of these properties in some more detail.

The property [+ occurring with telic modifiers], which characterises accomplishments and achievements, correlates in our table with the property of denoting an event of change. (Note that this is not the definition of telicity, but a **correlation** in the table in (4)). I will not develop a theory of change here, but will make do with the following working definition:

- (5) A change from  $\beta$  to  $\alpha$  is an event whose minimal initial part is the last instant  $i$  at which  $\beta$  holds and whose minimal final part is the first instant  $i'$  at which  $\alpha$  holds." (Dowty 1979, Rothstein 2004).

It follows from (5) there are two possible kinds of changes: extended changes where  $i$  and  $i'$  are not adjacent but separated by an interval, and non extended changes where  $i$  and  $i'$  are adjacent. (An interval is a concave set of instants, or a set of temporally adjacent instants without gaps.) We characterise the non-extended changes as changes from  $\alpha$  to  $\neg\alpha$ : on the assumption that either  $\alpha$  or  $\neg\alpha$  is true of every instant, a change from  $\alpha$  to  $\neg\alpha$  must be instantaneous. We characterise extended changes as changes from  $\beta$  to  $\alpha$  where  $\beta$  entails  $\neg\alpha$ . Extended changes are accomplishments and non-extended changes

are achievements. The two kinds of non-change events are in the denotations of state and activity predicates.

The [+ occurrence with progressive] characterises activities and accomplishments and distinguishes them from states and achievements. The semantics of the progressive, no matter whose semantic theory one adopts, makes a sentence such as *A is V-ing* true if there is a possibly incomplete event in the denotation of *V* going on. Landman (1992) argues that the progressive makes reference not just to parts of events, but to stages, where *e* is a stage of *e'* if *e'* is a development of *e*. It follows from his theory of stages (developed in Landman 2004) that if *e* is a stage of *e'*, *e* and *e'* must be qualitatively different. We can use these ideas to explain why the progressive does not occur naturally with either states or achievements. States are totally homogeneous down to instants. This means two things. First, the shortest states hold at instants, and second, each instant or interval at which a state holds is identical in the relevant respects to every other instant or set of instants at which it holds. This means that states can not have stages, and thus an operation such as the progressive which makes reference to stages cannot apply to states.

Achievements also do not occur with the progressive. Achievements are events of instantaneous change from  $\alpha$  to  $\neg\alpha$  which consist of two instants, the last instant *i* at which  $\alpha$  holds and the first instant *i'* at which  $\neg\alpha$  holds, where crucially there is no instant intervening between *i* and *i'*. While these events are not strictly instantaneous, since they consist of two minimal instants, they are also not extended since there is no interval intervening between their initial instant and their final instant. They are thus not naturally divisible into stages, and not appropriate inputs to the progressive construction. (I show in Rothstein 2004 that where achievements do seem to occur in the progressive, this is because there has been a shift in the VP meaning from an achievement-type event to an accomplishment-type event, where the lexical achievement denotes the event which is the culmination of the accomplishment. For details see Rothstein 2004 chapter 2.)

Thus, the inability to occur with the progressive reflects a property common to both state and achievement events, namely that they are not inherently extended in time, and that they are therefore not naturally analysable into stages. States may hold at instants or a concatenation of instants, while achievements hold at concatenations of two adjacent instants which cannot be extended. In contrast, both activities and accomplishment take time. Accomplishments involve an incremental process (Dowty 1991, Krifka 1992, Rothstein 2004) and, as Dowty (1979) argued extensively, activity predicates cannot be true of instants but only of intervals defined by at least two non-adjacent instants. Thus in order to see whether it is true that John ran, it is necessary to have evidence as to what occurred at least two (but possibly more) related but non-adjacent instants and to compare the state that John was in at each instant, and then to decide whether the relation between the properties of these two

instants is such that we can conclude that an event in RUN was going on. The same is true if we evaluate whether *Mary built a house* is true. The fact that, for an event  $e$  in  $P$ , different things are going on at different non-adjacent instants of  $e$  is evidence that  $P$  denotes a set of events that can be analysed as having stages, and thus the progressive naturally applies.

The table in (6) sums up this discussion:

(6)

	Minimal events are extended	Event of change
States	–	+
activities	+	–
achievements	–	+
accomplishments	+	–

The table expresses that event predicates vary as to whether the (minimal) events in their denotations are (near-) instantaneous or extended, and as to whether or not they are events of change. Achievements denote non-extended events of change; accomplishments denote extended events of change; states denote non-inherently extended events which do not involve change and activities denote inherently extended events not involving change. Note that following Rothstein 1999, I assume that all verbs have their denotations in the count domain.

### 3 Cumulativity

An obvious question to ask is what is the relation between the classification of verb denotations in (6) and other characterisations of properties of verb meanings. It will be particularly fruitful for our discussion of semelfactives to examine the relation between the table in (6) and Krifka's (1992,1998) classification of verb meanings in terms of whether they allow cumulative reference. Allowing cumulative reference is a property of states and activities, and therefore distinguishes between the verb meanings marked [+ telic] and those marked [– telic] in the table in (6)

Cumulativity is a property taken from Link's 1983 discussion of the mass count distinction in the nominal domain. A predicate  $X$  is cumulative (allows cumulative reference) iff:

- (7)  $\exists x \exists y [X(x) \wedge X(y) \wedge \neg x \sqsubseteq y \wedge \forall x \forall y [X(x) \wedge X(y) \rightarrow X(x \sqcup y)]]$   
 "X is cumulative if when two distinct elements  $x$  and  $y$  are in  $X$ , the sum of  $x$  and  $y$  are also in  $X$ ."

(7) distinguishes between mass and plural predicates on the one hand and singular predicates on the other: two quantities of water put together gives an entity in the denotation of *water* and two pluralities in the denotation of *books* summed together give a plural entity in the denotation of *books* but the sum of two entities in the denotation of *book* or *dog* do not give an entity in the same set *book* or *dog* but in the plural set *books* and *dogs*.

Krifka argues that the distinction between cumulative and non-cumulative predicates is relevant in the verbal domain as well, and that it distinguishes roughly between predicates which we call atelic and those we call telic. (Krifka does not define telicity in terms of cumulativity, but since we are interested in what cumulativity is, this shouldn't bother us at the moment.) The intuition is that two separate but temporally adjacent running events can be summed into an event of running, while two separate, temporally adjacent events of eating three apples or drinking a glass of milk cannot be summed into an event in the denotation of *eat three apples* or *drink a glass of milk*. This is illustrated in (8)

- (8) (a) If John ran from 13.00 to 14.00 and he ran again from 14.00 to 15.00, then he also ran from 13.00 to 15.00. (= cumulative)  
 (b) If John ate (exactly) three apples between 13.00 to 14.00 and then he ate (exactly) three apples between 14.00 and 15.00, then it is not the case that he ate exactly three apples between 12.00 and 15.00.

The contrast between (8a) and (8b) is clear; however, a closer look shows that cumulativity is not the right way to capture it. This is because the definition of cumulativity makes reference to the effect of operation of summing entities (singularities and pluralities), and the output of the summing operation is itself a plurality. In the nominal domain the property of cumulativity distinguishes between the effects of summing on predicates denoting unmeasured plurals and mass elements on the one hand, and individual count elements on the other hand. When the summing operation sums pluralities and non-singular entities, it gives as output the same kind of plural and non-singular entities that were the input, but where the summing operation applies to singular entities, it gives pluralities as output. The distinction shows up clearly because nominals usually encode plurality morphologically, and thus it is clear that a sum of entities in *dog*, will result in a plurality which cannot itself be an element of *dog*, but only of *dogs*.

However, the verbal domain does not morphologically encode plurality. VPs denote sets which include both singular and plural events (see e.g. Landman 2000); so sums of singulars and sums of plurals in the denotation of VP ought still to be in the denotation of the same VP for both telic and non-telic VPs. And indeed, they are:

- If John ate three apples and Mary ate three apples, then the plural event of both of them eating three apples is in the denotation of *eat three apples*, illustrated in (9a):
- If Mary ate three apples and then ate three apples again, then the sum of those two events is in the denotation of *eat three apples*, illustrated in (9b):

- (9) (a) Who ate three apples? John and Mary ate three apples. (in all six apples were eaten)  
 (b) Mary ate three apples twice. (In all six apples were eaten).

But this means that so-called telic VPs are cumulative too.

If so, then what is the basis of the distinction between *run* and *eat three apples* illustrated in (8a)?

The contrast in (8) expresses the fact that two activity events (or two state events) can be summed and the result can be treated not just as a sum, or plurality, but as a new **singular event**, and that this cannot be done with two events in *build a house*, *eat three apples* or *arrive*. Thus the contrast in (8) stems from the following fact about language:

-If John ran from 1pm to 2 pm and then from 2pm to 3pm, then there is a singular event in the denotation of *John run* which lasted from 1pm to 3pm.

-If John ate exactly three apples between 1pm and 2 pm and then again between 2pm to 3pm, then the sum of these events cannot be formed into, or conceptualised as, a singular event in the denotation of *eat three apples*.

The formal property which captures the distinction between *run* and *eat three apples* is what we might call S-cumulativity:

- (10)  $\exists e \exists e' [X(e) \wedge X(e') \wedge \neg e \sqsubseteq e' \wedge \forall e \forall e' [X(e) \wedge X(e') \wedge R(e, e') \rightarrow X({}^S(e \sqcup e'))]]$   
 "A predicate X is S-cumulative if any two distinct instances of X related by the 'R' relation can be summed, and the sum formed into a singular entity which is itself in the denotation of X."

We assume that, as far as events are concerned, the R relation is temporal adjacency, in other words, two events e and e' can be summed and the resulting sum can be formed into a singular entity if no other event intervenes between them. (Rothstein 2004, chapter 7, discusses S-cumulativity in the nominal domain, where the R relation is not temporal adjacency.)

This property of being S-cumulative is what distinguishes states and activities on the one hand from achievements and accomplishments on the other. Two adjacent events e and e' of x loving y (or of x running) can be conceptualised as a single event, e" which is itself in the denotation of *love* (or *run*). Thus we can describe the set of activities and states as being closed under the operation of S-cumulativity. Two adjacent events of arriving or of eating an apple cannot be reanalysed as a single event in the denotation of *arrive* or *eat an apple* and therefore the predicates are not S-cumulative and accomplish-

ments and achievements denote sets which are not closed under S-cumulativity.

Assuming the correlation between telicity and lack of S-cumulativity is not coincidental, then we should ask why S-cumulativity does not apply to telic predicates i.e. predicates of change? Remember that we observed that telic predicates are events of change. As Kamp (1979a,b) argues, two events in the denotation of a predicate of change P (with the same participants) cannot be immediately temporally adjacent to each other, since a change from  $\alpha$  to  $\neg\alpha$  cannot be immediately followed by another event of change from  $\alpha$  to  $\neg\alpha$  without an intermediate event of change from  $\neg\alpha$  back to  $\alpha$ . Since S-cumulation requires the summed events to be temporally adjacent, it follows that predicates of change (i.e. those marked [+telic] in (6)) cannot be S-summed.

#### 4 Semelfactives

Semelfactives are verbs such as *kick, knock, jump, skip, flap(its wings), wink*, which denote single actions, in the sense that *knock(on the door)*, for example, may be understood as denoting a single event in which an object is brought in contact sharply with a door **once**. These events can be counted: (11a) asserts that John brought an appropriate object in contact with the door three times and (11b) that he left the ground by jumping three times.

- (11) (a) John knocked three times.  
 (b) John jumped three times.

When they occur in the progressive **with a semelfactive reading** they induce the imperfective paradox. Each of the examples in (12) can be used to describe a situation in which a single knock or a single kick was interrupted:

- (12) (a) John was knocking hard when he saw me, so he turned it into a tap instead (and didn't knock hard).  
 (b) Bill was kicking him when he saw me, so he stopped midway (and didn't kick him).

The fact that these induce the imperfective paradox indicate that semelfactives are quantized (in the sense of Krifka 1992, 1998). They denote minimal events such that if  $e$  is in the denotation of a semelfactive predicate no part of  $e$  is also in the denotation of that predicate. They also occur with the telic temporal modifiers *in a time*. In a context of a pole vault or, a slow motion film, (13) is acceptable on the single event reading:

- (13) John jumped in three seconds.

However, all semelfactives are homonymous with activity predicates, and these activity predicates occur with atelic temporal modifiers, and do not induce the imperfective paradox:

- (14) (a) John knocked on the door (repeatedly) for several minutes/half an hour.  
 (b) John was knocking on the door when I arrived. (So he had knocked.)

Importantly, as we shall see, while all semelfactive predicates have a homonymous activity reading, not all activities have a homonymous semelfactive reading. *Run*, *swim*, and *walk* have only activity readings.

The question is where semelfactives fit into the schema in (6). Smith (1991), who is probably most responsible for the consensus that semelfactives constitute a real class of verbs, argues that they are really atelic achievements. She phrases this by saying that semelfactives are dynamic, atelic, and instantaneous, while achievements are dynamic, telic, and instantaneous. Her intuition is that semelfactives are, like achievements, single stage events, which, though they take time/have duration, are conceptualised as instantaneous. They differ from achievements which are also single stage events, since achievements are events of change, while semelfactives do not bring about a change. While it seems clear that Smith is right that achievements and semelfactives differ in that the former is a predicate of change and the latter not, there are two problems with her account. The first is that it does not explain why semelfactives occur with *in a time* (and other telic modifiers). The second is that while achievements really are non-extended, consisting of two temporally adjacent instants, semelfactives really take time and are temporally extended. An event in the denotation of *arrive* has no internal structure; it consists of the last instant at which *x* is not at location *l* and the first instant at which *x* is at location *l*, and there is no gap between these instants. But, semelfactives do have internal structure. *Jump*, *flap a wing*, *kick* and *wink* all have trajectories, in the sense that for an event of knocking to occur, several things have to happen at different non-adjacent instants: an object has to be brought sharply through space to come in contact with a hard surface. For an event of winking to occur, an eye has to close and then open again, and so on. If semelfactive events are defined via trajectories, then they cannot be instantaneous, and, unlike achievements, they must be [+temporally extended] in the table in (6). So semelfactives, like activities and accomplishments, hold at minimal intervals and not at instants. Like accomplishments they are quantized, they induce the imperfective paradox and they occur with *in a time*, but unlike accomplishments, they do not denote events of change. They are unlike activities, which occur with atelic modifiers, and which are not quantized, but they are homonymous with activities. So it seems appropriate to explore the relation between semelfactives and activities further.

As we already pointed out, semelfactives have a related activity reading, which seems to be an iteration of the single event reading, so that *jump* can denote either events of single-occurrences-of-leaving-the-ground or iterations of these events. However, not all activities are related to semelfactives. The activity *run* cannot be used as a semelfactive, and this results in a set of systematic differences between *run* type predicates and *jump* type predicates:

i. Counting adverbials can count either the single events or the iterations for *jump* type predicates. With *run*, only extended events can be counted.

Compare *run* with *jump*:

- (15) (a) Dafna jumped/skipped once/twice.  
 (b) Dafna ran once/twice.

ii. When *in a time* is used as a modifier, it induces the semelfactive reading on *jump* type predicates, and measures the time of a single jump. When the same modifier is used with *run*, a contextually determined measure for the extended event is required, and the modifier measures the time of the extended event:

- (16) (a) Dafna jumped in two minutes.  
 (b) Dafna ran in two minutes.

iii. *Again and again* can modify either the single event or the activity predicate with *jump*. The semelfactive reading in (17a) can be paraphrased by (17b). Since there is no semelfactive reading for *run* in (17c), *again and again* can only modify the extended reading, and thus (17d) is not appropriate as a paraphrase.

- (17) (a) She jumped again and again  
 (b) She jumped for several minutes.  
 (c) He ran again and again.  
 (d) He ran for several minutes.

iv. Note also that the nominalisations of *jump* type predicates denote single events, and occur naturally with the light verb *give*, while nominalisations of *run* denote extended events and occur with *have*:

- (18) (a) He gave a jump/a kick/ a wink.  
 (b) He had a walk/a run/a swim.

So, activities come in two kinds; those that are related to semelfactives and those that are not. The kind that are related to semelfactives seem to denote an iteration or repetition of the single event in the denotation of the semelfactive.

At this point, we go back to Dowty's (1979) discussion of activities. Dowty (1979), in his discussion of the imperfective paradox, argues that, while *John is running* normally entails *John ran*, it does not have this entailment if the running event is in its initial stages. He shows that that some minimal interval must pass at the beginning of an activity event  $e$  in  $P$  before one can say that an event in  $P$  has happened, and comes to the conclusion that (i) all activities are related to a 'minimal' activity event, and (ii) all non-minimal activities can be seen as concatenations of minimal events. He argues further that it is not normally possible to define the minimal event, but stresses that it holds at an interval and not at an instant. (For more discussion see Dowty 1979 and the discussion of Dowty in Rothstein 2004.) Dowty does not discuss what operation forms activities from minimal activity events, but we are now in a position to address this.

An obvious candidate is the concatenation operation. On this account, activities would be concatenations of the single events in the denotations of semelfactives, but this cannot be correct, since concatenation is usually taken to be additive, which means it applies to non-overlapping entities. The operation here (as we will see below) applies to overlapping entities. It is a summing operation: a function from  $E \times E$  into  $E$  with the standard summing properties, but it must form a singular entity out of the two singular entities which are summed. This must be the case since extended events in the denotation of an activity predicate which by hypothesis are constructed out of minimal events none the less count as single events. Thus two minimal events of walking can get put together to make a single, non-minimal walking event, and so on. In general, there will be some condition on which elements can be put together via S-summing, which we express by saying that elements to be S-summed must stand in the R-relation, and define the operation S-summing (for singular summing), as in (19):

$$(19) \text{ S-sum: } \forall x,y [S\text{-sum}(x,y) \rightarrow R(x,y) \wedge {}^S(x \sqcup y)]$$

The operation defined in (19) is a general operation not restricted to the domain of events. When the entities involved are events, then  $R(e,e')$  iff:

- (a)  $e$  and  $e'$  are temporally overlapping  
i.e.  $\tau(e)$  and  $\tau(e')$  overlap, where  $\tau$  is a function from events to their running times.
- (b)  $e$  and  $e'$  have the same participants.

Clearly, S-sum is related to the property of S-cumulativity, which we repeat here from (10).  $X$  is **S-cumulative** iff:

$$(10) \exists e \exists e' [X(e) \wedge X(e') \wedge \neg e \sqsubseteq e' \wedge \forall e \forall e' [X(e) \wedge X(e') \wedge R(e,e') \rightarrow X({}^S(e \sqcup e'))]]$$

Clearly, it follows that a predicate is S-cumulative if and only if it is closed under S-sum. Since activity predicates are S-cumulative, they are closed under S-sum. It follows that activity predicates denote a set of events which hold at intervals and which are not conceptualised as changes, and that the set is closed under S-summing. We assume that all activity predicates, whether or not they are related to semelfactives denote sets of minimal events closed under S-summing in this manner.

We can now explain what the relation between semelfactives and activities is. Assume that all activity predicates denoting a set A are derived from a set of basic minimal activity events which we call MinA. In some cases, the minimal events can be lexically accessed and the predicate is ambiguous between: (a) the semelfactive reading in which it denotes the set of minimal activity events and (b) the activity reading in which it denotes the set closed under S-summing. The question is now why some activity predicates are ambiguous in this way and others are not. I suggest that the ambiguous predicates, those where the minimal events can be lexically accessed, are those where the minimal events are **naturally atomic**. A naturally atomic entity is one whose unit structure is perceptually salient and given by the world. Most objects in the denotation of non-abstract nominals in the count domain are naturally atomic in this way: *person*, *cat* and *cup* are all naturally atomic, since in a situation in which there are a number of humans or cats or cups, what counts as one of each is in some basic sense given. But even in the domain of concrete entities, not all count nouns denote sets of naturally atomic entities. Rothstein (1999,2004) discusses nouns such as *fence*, *wall*, and *lawn*, which denote non-abstract objects whose unit structure is contextually determined.

A naturally atomic event is one which has a natural beginning and end point, determined by the trajectory which defines the event. If we look at the diagrammatic representations of a stretch of jumping and running events, given below, it is clear that the set of jumping events can naturally be divided into individual minimal jumping events, with the beginning and the endpoints of the events indicated by the arrows, representing the points where the jumper leaves and returns to the ground.

### Jump:



### Run:



In contrast, no such natural intuitive division into atomic minimal events is possible in the case of *run* since minimal running events do not have naturally

defined beginning and endpoints. Instead, any one of a set of overlapping events could be considered a minimal running event. I suggest that only when the minimal events in a set of activity events are naturally atomic in this way are they lexically accessible. When a set of minimal activity events is naturally atomic, then the predicate is ambiguous between a 'normal' activity reading, where it denotes the set closed under S-summing and a semelfactive reading when it denotes the set of minimal activity events. This is the case with *jump*-type predicates. When the minimal events are not naturally atomic, then the set of minimal events is not lexically accessible, and the predicate has only the reading where it denotes the complete set of activity events.

The analysis that I have just given is an analysis of the semelfactive-activity relation in English. Nonetheless, it has implications for other languages. The distinction between minimal events and events derived under S-summing should be a feature of all languages which have activity predicates, and the implied constraint that minimal events which are not naturally atomic are not lexically accessible is also a constraint which should not be language specific. But, there is no reason why other languages should express the contrast between minimal events and extended events in the way English does, namely via an ambiguous predicate, and we would expect other languages to lexicalise the distinction differently. Preliminary investigation of some Slavic languages indicates that the activity/semelfactive distinction is indeed lexicalised differently, with activity verbs having imperfective aspect, and semelfactives having perfective aspect and being derived from activity predicates via affixation.

## 5 The S-summing operation

If the S-summing operation is not just a device to relate semelfactives and activities, then it ought to be a general operation available for deriving lexical predicates in all lexical classes, and not an operation which is stipulated to apply to minimal activity events. But if it is a generally available operation, then we want to explain why its effects are only visible in the relation between minimal activities and semelfactives. There are two possible explanations. Either it operates on other lexical classes in such a way that its effects aren't seen, or it is prevented from applying to other classes in some principled way.

A closer look shows that S-summing can be treated as a generally available operation, and that both of the two possible explanations are relevant. When S-summing applies to other atelic predicates, its effects are not visible, and it is prevented from applying to so-called telic predicates in a principled way.

The second, non-activity, class of atelic predicates is the class of states. These are cumulative, according to Krifka (1992, 1995) and S-cumulative according to the definition given in (10) above. Two events of *x* loving *y*

which are temporally adjacent can be conceptualised as a single event of  $x$  loving  $y$ , and states are infinitely extendable. However, we do not get the distinction between state predicates denoting the set closed under S-summing and state predicates denoting sets of minimal state events because minimal state events are not naturally atomic. They are not naturally atomic for a structural reason. Minimal states hold at instants, and under the assumption that time is dense, and that any instant can be split into two instants, there is no set of naturally atomic minimal state events available, and therefore no set of such states which is lexically accessible.

In contrast, S-summing is prevented from applying to achievements and accomplishments because, as we already noted above, they cannot meet the conditions under which it applies. S-summing applies to two events which are temporally adjacent. However, the definition of change means that achievements and accomplishments will never be able to meet this condition. Assume, that events have initial and final parts determined by the initial and final intervals of their running times, such that  $M\text{-IN}(e)$  = the minimal initial interval at which  $e$  holds and  $M\text{-FIN}(e)$  = the minimal final interval at which  $e$  holds. A change from  $\alpha$  to  $\beta$  is an event whose minimal initial part is the last minimal interval at which  $\alpha$  holds and whose final minimal interval is the first minimal interval at which  $\beta$  holds, where  $\alpha$  entails  $\neg\beta$ . (Rothstein 2004). But it follows from this that an event of change defined in this way will never meet the conditions of S-summing since a change from  $\alpha \wedge \neg\beta$  to  $\beta$  can never be immediately followed by another event of the same type with the same participants since, as Kamp (1979b) argues, two events of change from  $\neg\beta$  to  $\beta$  must be separated by a change back from  $\beta$  to  $\neg\beta$ . This corresponds with the basic intuition that, for example, John cannot arrive at the same place twice unless he leaves after the first event and before the second event. Similarly, the same house (or puzzle) cannot be constructed twice unless it is taken to pieces after the first event and before the second event begins.

Kamp (1979a,b) argues that because of the density of time, two apparently temporally adjacent instants will always be separated by an intervening instant, and if we accept this, then S-summing will apply only to events which overlap temporally. Under this assumption, we can state that with activities and states, for two events  $e$  and  $e'$  in  $P$ , it is possible that the minimal final part of  $e$  is the minimal initial part of  $e'$ . With accomplishments and achievements this is not possible because of the structure of the event of change. This means that S-summing can not apply to events of change.

We can now draw some conclusions about the table in (6). The features there give us the possible **minimal** events. Minimal states are non-extended and not events of change. Minimal activities are extended verbs of non-change. Achievements are non-extended verbs of change and accomplishments extended verbs of change. There is a generally available operation of S-summing which applies freely where conditions of application are met. It cannot apply

to achievements and accomplishments but does apply to states and activities. Lexical predicates denote sets of minimal events closed under S-summing. Only naturally atomic minimal events are lexically accessible; thus minimal states are not lexically accessible, and only some activity predicates have naturally atomic minimal events. When a predicate does denote a set of non-minimal events whose minimal events are naturally atomic, the predicate is ambiguous between a reading in which it denotes the minimal events – the semelfactive reading – and the reading in which it denotes the whole set.

Semelfactives then, are minimal atomic events in the denotations of some activity predicates. An obvious and important puzzle is why, since activity predicates are not telic, do semelfactives have the properties which we associate with telic predicates? As noted above, they occur naturally with *in a time* and other telic modifiers, and they induce the imperfective paradox. In this they pattern with achievements and accomplishments and not with activities. And yet, according to the analysis developed here, they are firmly located, in terms of features, with the activity/state group.

The explanation for this apparent paradox is that occurring with telic modifiers is not the defining characteristic of accomplishments and achievements; rather what characterises them is the property used in the table in (6), namely that they are predicates denoting events of change. A telic predicate is not one which denotes an event of change, but one which denotes a set of atomic entities. A predicate *P* is telic if it has as part of its lexical content the information about what counts as one instance of *P*, in other words if the individual countable units of *P* are given independent of context, and if we can count, independent of context, how many individuals there are in *P*. However, while telicity is not synonymous with being a predicate of change, predicates of change are naturally telic predicates. This is because changes are atomic, and the beginning and endpoints of events of change are determined by the beginning and end of the change.

States and activities, we saw, are not telic since they are closed under S-summing: a state or activity predicate *P* denotes a set containing events which have as parts events which are also in *P*, and pairs of events which can be S-summed into other singular events in *P*. These are not atomic sets since there is in principle no context independent way to count the number of events in the set, since both events and their subparts may, in different contexts, count as one event.

Semelfactive predicates, however, do denote atomic sets, since they denote sets of naturally atomic events which, although they may have a very large cardinality, are countable independent of context. Thus while they are like achievement and accomplishment predicates in denoting atomic sets, the basis for the atomicity is different. Nonetheless, all three varieties of predicates are telic.

Our account has led us not only to an explanation of the relation between semelfactives and activities, but also to a characterisation of telicity in terms of atomicity. This means that events of change will be telic, since the characterisation of what a change is itself constitutes criteria for individuating individual changes (an individual change from  $\alpha$  to  $\beta$  just is the event which begins at the last moment that  $\alpha$  holds and stops at the first moment that  $\beta$  holds.) However, this is consistent with their being telic predicates whose atomic units are determined in some different way. Semelfactives denote sets of atoms, but their atomic elements are determined not by a definition of change but by the natural salience and individuability of the elements which count as atoms. Presumably these follow from properties of the physics of motion and other relevant 'real world' facts.

Semelfactives, then, like accomplishments are minimal atomic events which hold at intervals. The crucial property distinguishing semelfactives from accomplishments is that, though telic, they are inputs to the operation of S-summing, which means that activities can be formed out of them. It is the characterisation of accomplishments and achievements as events of change which means that S-summing cannot apply.

## 6 Degree Achievements

Our analysis makes a prediction: if there are events of change which are not characterised as changes from  $\alpha$  to  $\beta$  where  $\alpha$  entails  $\neg\beta$ , and where two events of change can overlap, then S-summing should be possible, and we should find predicates which are ambiguous between denoting a set of minimal events and denoting a set of extended iterated events. I should like to suggest that degree predicates are examples of exactly this.

Degree achievements are discussed in Dowty (1979), Abusch (1985, 1986) and more recently in Hay, Kennedy, and Levin (1999) and Kennedy and Levin (2001). They include verbs such as *cool*, *brighten*, *redde*n, *widen*, and *darken* and as was argued by Dowty and Abusch, they appear to belong to more than one lexical class. To start with they have the properties of achievements. They denote instantaneous changes, as in (20), and when modified by telic modifiers such as *in half an hour*, the modifier locates the change in time, i.e. at the end of half an hour, without entailing that the change took place gradually during half an hour, as in (21):

- (20) (a) In an instant, the sky brightened.  
 (b) When I switched off the light the room darkened.
- (21) (a) The sky brightened in half an hour (= at the end of half an hour)  
 (b) It took half an hour for the sky to brighten.

Furthermore, when used with the futurate progressive, a telic modifier locates the end point of the event, which Rothstein (2004) argues is a clear test for an achievement:

- (22) (a) The room is darkening in a couple of minutes.  
 (b) The weather is cooling in three days.

However, in addition to the achievement reading, they can also denote extended events in which they are ambiguous between an activity and accomplishment reading depending on whether the sentence is understood as asserting that the event reached some specified point. (Abusch 1985, 1986) Thus (23a) can be interpreted as *the soup became cooler* or *the soup became cool* and there is a similar ambiguity in (23b):

- (23) (a) The soup cooled.  
 (b) The room/sky darkened.

If we use the imperfective paradox, then we get conflicting entailments, depending on whether the verb is interpreted as reaching a determined culmination or not. If *cool* is interpreted as *become cool*, then *the soup was cooling* does not entail *The soup cooled*, since the fact that it was cooling does not entail that it became cool. If *cool* is interpreted as *become cooler*, then the entailment does go through, since *the soup is cooling* does entail that it became cooler. This data supports the claim that *cool* is ambiguous between an activity and an accomplishment reading. Further, when *cool* denotes an extended event, it can occur with both atelic and telic modifiers. In the first case it means *become cooler* and in the second it means *become cool*.

- (24) (a) The soup cooled for hours.  
 (b) The soup cooled in half an hour.

So an account of the lexical semantics of degree achievements needs to explain how these achievement, activity and accomplishment readings are all derived. Degree achievements are almost always derived from adjectives. Adjectives are naturally analysed as denoting functions from individuals to values on a specified scale (see Kennedy 2001 and references cited there). *The soup is cool* entails that the soup has a value on the temperature scale that is below a certain value. We assume that adjectives have generally the semantic structure in (25), denoting functions from individuals to values on a scale, where  $\approx$  represents a choice between  $=$ ,  $<$  and  $>$ , and  $d$  is a variable over values on the scale. The meaning of *cool* and *hot* would be represented as in (26), where  $s_{\text{COOL}}$  and  $s_{\text{HOT}}$  are the cool-scale and the hot-scale respectively (I assume that scales are

pairs of degrees, or measures, and the domain of the measurement, so that S-COOL will be a pair consisting of <Celsius, Temperatures> . In fact, this means that S-COOL and S-HOT will be the same scale, but I won't discuss this any further here.)

$$(25) \parallel \text{ADJ} \parallel = \lambda x. V_S(x) \approx d$$

$$(26)(a) \quad \parallel \text{COOL} \parallel = \lambda x. V_{S\text{-COOL}}(x) < d$$

$$(b) \quad \parallel \text{HOT} \parallel = \lambda x. V_{S\text{-HOT}}(x) > d$$

*The soup is cool* will then have the interpretation in (27):

$$(27) \parallel \text{The soup is cool} \parallel = V_{S\text{-COOL}}(\text{THE SOUP}) < d$$

This asserts that the value assigned to the soup on the COOL scale (=  $S_{\text{CELSIUS, TEMPERATURE}}$ ) is less than a contextually determined standard,  $d$ .

Adjectival constructions of this kind are inherently comparative, and explicit comparative constructions allow the standard of comparison to be expressed. (28) is an example of this:

$$(28)(a) \quad \text{The soup is cooler than the sauce.}$$

$$(b) \quad V_{S\text{-COOL}}(\text{THE SOUP}) < V_{S\text{-COOL}}(\text{THE SAUCE})$$

This asserts that the value assigned to the soup on the COOL scale is less than the value assigned to the sauce on the COOL scale.

Against this, what can we say about the interpretation of the verb *cool*? There must be three elements to its meaning. Like the adjective, from which it is derived, it will relate an object to a value on a scale. It will also involve some comparison, and, as a verb, it will denote a set of events, presumably events of change. If (27) compares the temperature of the soup with a standard value, and (28) compares the temperature of the soup with the value assigned to the sauce, then *the soup is cool* compares the temperature of the soup at the end of the event with the value assigned to it at the beginning of the event. The verb *cool* then, denotes the set of events in which an object  $x$  is assigned a lower value on the temperature scale at the end of the event than it was assigned at the beginning of the event.

$$(29) \parallel \text{COOL}_V \parallel = \lambda e. V_{S\text{-COOL}}(x, \text{M-FIN}(e)) < V_{S\text{-COOL}}(x, \text{M-IN}(e))$$

*cool* denotes the set of events in which the temperature of  $x$  at the minimal final interval of  $e$  is lower than the temperature of  $x$  at the minimal initial interval of  $e$ .

So a cooling event is an event of change from a situation in which  $x$  is assigned  $d$  on the COOL scale, to a situation in which  $x$  is assigned a value lower than  $d$  on the COOL scale.

How does this allow us to account for the properties of *cool*, and other degree adverbs noted above? Note first that this analysis assigns only one meaning to *cool*, that of becoming cooler, since it constrains the value of  $x$  on the temperature scale only at the end of the event only relative to its value at the beginning of the event, and not in absolute terms. This means that we are disagreeing with theories such as Abusch (1985, 1986), who argue that these verbs are ambiguous. The meaning given in (29) specifies the direction of change of value on the scale, without giving any constraints on or absolute properties of the final value. Evidence in favour of this is that *cool* does not mean the same as *become cool* since *cool* dictates the direction of the temperature change, while *become cool* does not. So while *the soup cooled* entails that the temperature of the soup decreased, but does not specify its final value, *the soup became cool* does specify the properties of the final value but does not constrain the direction of the change. Thus we have the contrast in (30):

- (30) When I took the soup out of the fridge it was so cold that it burned my mouth, but after some time at room temperature, it had become pleasantly cool/\*it had cooled.

So *cool* means 'undergo a decrease in temperature', as in (29) and not 'get a value in the cool range, while *become cool* means: 'get to have a temperature value in the (contextually determined) cool range' without specifying the direction of change.

Now let us look at how the various lexical properties of *cool* are explained by this analysis.

(i) *Cool* is a degree achievement. It denotes a set of instantaneous changes, where the change is a situation in which  $x$  is assigned a value  $d$  on the cool scale, to a situation in which  $x$  is assigned a value lower than  $d$ . This change is not inherently extended. (31) is perfectly coherent:

- (31) When I dropped the ice in, the liquid cooled instantly (although not very much).

This *cool* denotes a set of minimal (non-extended) changes from  $\alpha$  to  $\beta$ , where there is no interval intervening between M-IN(e) and M-FIN(e).

We will call the denotation of cool as a degree achievement COOLMIN.

On this reading *cool* has all the properties of achievements noted above. In these cases, *x cooled* entails  $x$  became cooler and not  $x$  became cool, since (29) expresses only the relation between the values of  $x$  at the beginning and end of the event and not the extent of the change itself.

However, unlike 'normal' achievements, the change events in the denotation of *cool* are not lexically characterised as a change from  $\alpha$  to  $-\alpha$ , but as a change in values on a scale. Crucially, as well as being the degree of coolness

of  $x$  at the end of  $e$ ,  $d$  can also be the degree of coolness of  $x$  at the beginning of  $e'$ , where  $e$  and  $e'$  temporally overlap. Thus for an event  $e$  in COOL,  $V(x, M\text{-FIN}(e))$ , the value assigned to  $x$  on the cool scale can be the starting point for another event of change  $e'$ , where  $e$  and  $e'$  overlap temporarily. In other words, it is possible that  $V(x, M\text{-FIN}(e)) = V(x, M\text{-IN}(e'))$ . This means that the conditions for S-summing are met, and we expect degree achievement predicates like *cool* to be closed under S-summing. We expect the set COOLSUM to be events in the set COOLMIN closed under S-summing, and for the events in COOLSUM to have the properties of activities.

(ii) *Cool* is an activity. On this reading it denotes the set COOLSUM, the set of cooling events closed under S-summing. On this reading, the verb appears with atelic modifiers and the imperfective paradox will not hold:

- (32) (a) The soup was cooling.  
 (b) The soup cooled for three hours.

(32a) entails that the soup has already cooled (somewhat), and (32b) entails that the soup cooled for some interval of three hours and for all subintervals of the three hours. So *cool* on this reading is an activity, but a special activity since it is derived from an achievement via the S-summing operation.

(iii) Is *cool* also as an accomplishment? Despite the evidence above, we do not need to argue that *cool* is also an accomplishment, even when it seems to mean *become cool* and to have an inherently determined culmination point. The grammar already provides us with a way to explain constructions like *the soup cooled in three hours*. All activities can be used to head VPs which are telic, in which case they seem to have the properties of accomplishments, and *cool* is just like other activities in this respect. The telicity of activity-headed VPs is determined either contextually or via extent modification, and the effect is to make the activity seem like an accomplishment. *Cool* behaves exactly like *run* in this respect. First, if there is a contextually determined extent to the event, it behaves as if it heads a telic VP:

- (33) (a) The soup cooled in half an hour.  
 (b) John ran in half an hour.

- (34) (a) Has the soup cooled yet?  
 (b) Has John run yet?

These examples imply a contextually determined extent to the cooling and running events. In such a context, (35) does not imply (36):

- (35) (a) The soup is cooling.  
 (b) John is running.

- (36) (a) The soup has cooled.  
 (b) John has run.

Degree modifiers provide an explicit extent to the activity event, also yielding a telic VP:

- (37) (a) The soup cooled three degrees.  
 (b) John ran three miles.
- (38) (a) The soup cooled 3 degrees in ten minutes.  
 (b) John ran three miles in half an hour..

When a degree modifier is present, not only is the telic modifier possible, as in (38), but the atelic modifier is impossible, as (39) shows:

- (39) (a) #The soup cooled down three degrees for hours.  
 (b) #John ran three miles for days.

## 7 Conclusions

Verb classes are defined by two sets of features: whether or not the event in its denotation is inherently temporally extended, and whether or not it denotes an event of change. There is an operation of S-summing, which forms singular events in P out of sums of temporally adjacent events in P. In the normal case, S-summing does not apply to verbs of changes, since two events of change from  $\alpha$  to  $\beta$  where  $\alpha$  entails  $\neg\beta$  cannot be temporally adjacent. The exception is with degree predicates, which are characterised as changes in values on a scale.

A number of other concepts have become important in the discussion. First is the notion of natural atomicity: some things come in inherently indivisible countable units, and others have their unit structure determined contextually. Semelfactives denote events that come with natural beginnings and endpoints, and therefore with a salient unit structure. Minimal events of running and walking don't have a natural breakdown into minimal parts. Activities, while they have their denotation in the count domain, do not have a naturally atomic structure, and what counts as an indivisible or countable unit is contextually determined, or determined via measure phrases as in (35-38) above.

Perhaps most important idea to come out of this discussion is that telicity crosses what we think of as the natural divisions of the verbs into classes, since semelfactives, which denote minimal activity events, behave as telic predicates

alongside accomplishments and achievements. The reason for this is that the telic/atelic distinction really has to do with the distinction between atomic and non-atomic sets: telic predicates denote sets of entities that are atomic in the sense that the criteria for what counts as 'one entity' are given, whereas with atelic predicates the criteria for picking out the units is determined by context, modifiers and so on. Atomic units can be determined in different ways: accomplishment and achievement predicates denote atomic events because of the notion of a change is essentially an atomic one (although in practice things are more complicated: see the discussion of telicity in accomplishments in Rothstein 2004). Semelfactives are atomic because 'of the way the world is', probably, if one looks at the lexical properties of the class of semelfactives, because the physics of certain kinds of movements means that they have natural beginnings and endpoints.

## 8. Appendix: deriving activities from accomplishments

I argued above that accomplishments cannot be S-summed, and that this is the crucial difference between semelfactives and accomplishments – both of which are quantized temporally extended events. This means that activities can be formed from semelfactives, but not from accomplishments. Apparent counterexamples to the claim that activities are not formed from accomplishments are sentences like (40a), which are acceptable, contrasting with the unacceptable (40b):

- (40) (a) I read Dafna The 101 Dalmatians for an hour before she went to sleep.  
 (b) #I built the house for a week.

The reason that this is not a real counterexample is that these activities are not derived via S-summing. We can see this, because S-summing sums minimal and bigger than minimal events in P, therefore the output of S-summing is always bigger than a single event. This we get the entailments in (41):

- (41) (a) I jumped for an hour ENTAILS I jumped at least once within the hour.  
 (b) The bird flapped its wing very slowly for a minute ENTAILS It flapped its wings at least once within that minute.

However, (40a) does not entail that I read The 101 Dalmatians to Dafna in under an hour. On the contrary, it asserts that the activity associated with the accomplishment went on for an hour, but implies that less than one accomplishment event in P happened. Thus (42a) is felicitously assertable, while (42b) is contradictory:

- (42) (a) I read *The 101 Dalmatians* for an hour and stopped in the middle of the fourth chapter. So we haven't yet read it even once.
- (b) The bird slowly flapped its wings for several minutes, but it was suddenly paralysed before it could flap its wings even once.

If activity events derived via S-summing must be long enough to include at least one minimal event, then these activity readings of accomplishments are derived differently. Since accomplishments are probably best analysed complex events consisting of an activity event and as an incremental process, it looks as if (40a) should be derived by reducing an accomplishment to a simplex verb by deleting the expression of the incremental process.

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