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Alex Lascarides' Solution to the Imperfective Paradox

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1 Introduction

The *imperfective paradox*, a popular problem from temporal semantics, has motivated many researchers to invest a lot of work into looking for a solution for quite some time. The problem can be sketched as follows: The progressive form of some verbs logically entails its corresponding non-progressive form, whereas for other verbs, it does not. For example, one thinks of (1) as to logically entail (2), but not of (3) as to entail (4):

(1) Max was running

(2) Max ran

(3) Max was building a house

(4) Max built a house

A solution to the imperfective paradox must correctly account for the different inferential behaviors of the above sentences by assigning to them logical forms that account for the entailment from (1) to (2), and block the entailment from (3) to (4).

Alex Lascarides has formulated such a solution in (Lascarides 1988) and (Lascarides 1991). Her approach improves on previous accounts in that it is a *principled solution*: It also accounts for other aspectual phenomena such as the interaction of the progressive with universal quantification. We will however not dwell on her treatment of those other phenomena here.

This article is to be understood as a brief summary of Alex Lascarides' solution. We will begin with exhibiting Vendler's (1967) classification of aspect in section 2, which serves as the foundation for Lascarides' approach. Another building block for for Lascarides' solution is an extended version of the interval-based temporal logic IQ by Richards, Bethke, van der Does & Oberlander (1989), laid out in section 3. Thereafter, section 4 explicates Lascarides' formulation of a classification of aspect in IQ. Her solution to the imperfective paradox itself is the topic of section 5, before section 6 concludes the article.

2 Vendler's Classification of Aspect

Zeno Vendler's (1967) classification of aspect will be a fundamental ingredient for Lascarides in solving the imperfective paradox. Vendler (1967) distinguishes between four aspectual classes of verbs, viz. *states*, *activities*, *accomplishments* and *achievements*, which are to be described below.

States (e.g. "love Mary") can occur over a period of time, but they are not to be confused with *activities* (e.g. "run"). Contrary to *states*, *activities* are processes that have definite start- and endpoints.

Accomplishments (e.g. "build a house") are more than *activities*. The difference is that besides invoking a process, *accomplishments* essentially involve a culmination point or conclusion. *Achievements* (e.g. "win the race") in turn also involve a culmination, but they do not necessarily invoke a prior process. A summary of Vendler's classification of aspectual classes is shown in figure 1.

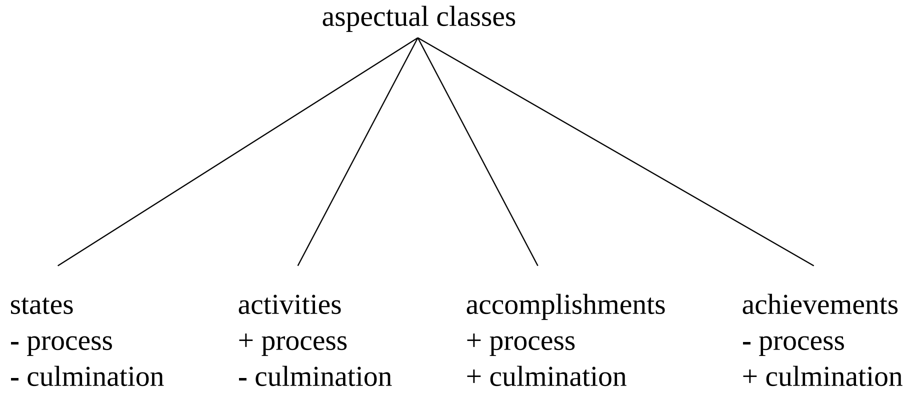

Figure 1: Vendler's classification of aspectual classes

Vendler's (1967) classification of aspect can now be used to achieve one fundamental part of a solution to the imperfective paradox. Examples (5) and (6) below demonstrate that the progressive form of *activities*, which do not invoke a culmination point, do entail their corresponding non-progressive form. In contrast, the progressive form of verbs that invoke a culmination (i.e. *accomplishments* and *achievements*) do not. *States* cannot occur in progressive form at all (Dowty 1979).

(5) Verbs that do not involve a culmination (states and processes)

a. $*$ "Max was loving Mary"

b. "Max was running" entails "Max ran"

(6) Verbs that involve a culmination (accomplishments and achievements)

a. "Max was building a house" does not entail "Max built a house"

b. "Max was winning the race" does not entail "Max won the race"

Hence Vendler's (1967) classification of aspectual classes seems to be a useful in predicting the inferential properties of different kinds of verbs in the interplay of their progressive and non-progressive forms. For this reason, Lascarides and others, e.g. Dowty (1979) and Cooper (1985), all make use of Vendler's distinctions in their solutions to the imperfective paradox. But for solving the imperfective paradox in a formal semantic framework, relying on Vendler's insight alone does not suffice. What is called for is a formal characterization of Vendler's classification, and that will be the topic of the following two sections. We will then be able to build on this formalization of Vendler's aspectual categories by defining the semantics of the progressive to solve the imperfective paradox.

3 An Introduction to IQ

Lascarides expresses her formal theory of aspect, which is later to solve the imperfective paradox, in the temporal logic IQ (standing for Indexical Quantification) by Richards et al. (1989). IQ has been originally developed to provide a formal semantic treatment of tense and temporal quantification in English and constitutes an interval-based framework in the sense that propositions in IQ are functions from world-interval pairs to truth values.

The language of IQ (henceforward referred to as Liq) is an extension of the ordinary predicate calculus. It contains the usual constants, variables, n-place predicates, truth functional connectives and quantifiers. The constants and variables are sorted into four domains in the extended version of IQ that Lascarides applies; they range over individuals, possible worlds, intervals of time and propositions.

Now the reader might ask why Lascarides chose to employ IQ as the framework within which she attempts to formulate a solution to the imperfective paradox. The reasons for the choice of IQ mostly hinge on two novel properties that the framework provides: The adherence to the so called *homogeneity principle* and IQ's notion of *parameters*, which are used to embed into logical forms extra-linguistic context. Both properties will be explicated just below.

3.1 The Homogeneity Principle

Lascarides' approach to solving the imperfective paradox was the first to employ with IQ a framework using a *homogeneous* interval structure. Other interval-based frameworks, like Dowty's (1979), make use of the *heterogeneouos strategy*: Accomplishment sentences such as "Max build a house"[1] are represented in (Dowty 1979) such that they are true at an interval i (the final bound of which is the culmination point of the accomplishment, i.e. the house is finished) and false at an interval j contained in i (the preparatory process, i.e. the house is not yet finished).

IQ is apart from Dowty's (1979) and other (heterogeneous) interval-based frameworks in that it entertains restriction (7), called the *homogeneity principle*:

(7) An atomic formula or a boolean combination of atomic formulae is true at a world-time index (w, i) only if for all subintervals j of i it is true at (w, j).

Hence in IQ, there can be no situation such that a sentence is true at an interval i and false at an interval j contained in i. This is the first leading idea in IQ, building the foundation for Lascarides' solution to the imperfective paradox.

3.2 Parameters

Another novel feature of IQ is a technique it supplies for representing deictic expressions, i.e. expressions that cannot be fully interpreted independently of extra-linguistic context. Deictic terms like "this" and "here" and also tensed sentences are represented in IQ by a set of referring expressions known as *parameters*. Parameters are assigned denotations to by a possibly partial function g_c (the *indexical function*), which is part of the model for IQ. As the context of the discourse to be considered changes, the denotations of the

[1] The choice of the infinitive in this example shall stress that the sentence is untensed.

parameters in the discourse representation also change, which allows the same sentence to denote different things in different contexts.

The parameters of Liq are sorted into the same four domains as its constants and variables, viz. individuals, possible worlds, intervals of time and propositions. They occur on deictic sentential tense operators for instance: The tensed version of an untensed sentence A is represented as $PAST_{(v,t)}(A)$, where v is a parameter which ranges over the domain of possible worlds, and t over the domain of intervals of time. The truth conditions of $PAST_{(v,t)}(A)$ are depicted in (8):

(8) $PAST_{(v,t)}(A)$ is true at the world-time index (w, i) if and only if $g_c(v) = w$, $g_c(t) = i$ and there exists an interval j earlier than i such that A is true at (w, j).

In the above definition, the indexical function g_c assigns the parameters v and t the appropriate possible world and time of speech. Parameters will later prove to be the second essential ingredient to Lascarides' formalism for solving the imperfective paradox, besides the homogeneity principle.

Now the background for Lascarides' choice of IQ as the formalism for solving the imperfective paradox is in place, and we will give the inevitable definitions of the syntax and the semantics of Liq. For the ones who despair upon the sight of three pages of definitions only: In section 3.5 just after the definitions, we will execute an example derivation of a formula from Liq to fill these definitions with life.

3.3 Syntax

The basic expressions of Liq are defined below:

1. Four countably infinite sets of *variables*: V_D, V_W, V_I and V_F.
2. Four (possibly empty) sets of *name constants*: C_D, C_W, C_I and C_F.
3. Four (possibly empty) sets of *parameters*: P_D, P_W, P_I and P_F.
4. For $n \geq 0$ a countably infinite set P^n of n-place *predicate constants*.
5. *Connectives*[2]: $\wedge$, $\vee$, $\rightarrow$, $\leftrightarrow$ and $\neg$.
6. *Quantifiers*: $\exists$, $\forall$. We read $\exists$ and $\forall$ as *some* and *all* respectively.
7. The set of D-terms is $V_D \cup C_D \cup P_D$, the set of W-terms is $V_W \cup C_W \cup P_W$, the set of I-terms is $V_I \cup C_I \cup P_I$ and the set of F-terms is $V_F \cup C_F \cup P_F$.
8. *Tense* operators: $PRES_{(v,t)}$, $PAST_{(v,t)}$, $FUT_{(v,t)}$, where $v \in P_W$ and $t \in P_I$.

The well formed formulas (wffs) of Liq are defined inductively:

[2]The syntax and semantics of connectives are missing in (Lascarides 1988) and (Lascarides 1991). We assume standard predicate logic connective syntax and semantics here.

1. Where R_n is an n-place predicate constant and $d_1, ..., d_n$ are D-terms, $R_n(d_1, ..., d_n)$ is an atomic wff.

2. Where A is a wff, $\neg A$ is a wff.

3. Where A and B are wffs, $A \wedge B$, $A \vee B$, $A \rightarrow B$ and $A \leftrightarrow B$ are wffs.

4. Where A is a wff and x belongs to V_D, $\exists x A$ and $\forall x A$ are wffs.

5. If A is a wff and Π is a tense operator, ΠA is a wff.

3.4 Semantics

Intervals in IQ are connected sets over points of time, and their ordering is determined by a partial ordering on the points of time. An interval i is earlier than an interval j if and only if all the points in i are earlier than all the points in j. An IQ-structure M is defined as follows.

M is a septuple $\langle D, W, I, F, \ll, g_c, f \rangle$ such that:

1. D, W and I are disjoint nonempty sets to be understood respectively as the set of individuals, possible worlds, and intervals of time. The non-empty set F is understood as the set of propositions. It consists of all functions from $W \times I$ to the truth values $\{0, 1, u\}$ (where u is to be glossed as *undefined*).

2. $\ll$ is the partial ordering of I induced by the ordering on the set of points of time.

3. g_c is to be glossed as the *indexical function*. It is a function from the parameters of Liq to corresponding denotations.

4. f is a function which assigns to the constants of Liq (possibly partial) intensions from $W \times I$.

   The interpretation function f is subject to the following *homogeneity restrictions*:

   a) For every name constant b and predicate constant R_n, $f(b)(w, i)$ and $f(R_n)(w, i)$ are defined for all (w, i) in $W \times I$, where i is a singleton (i.e. i is a point of time).
   b) For all name constants b, $f(b)(w, j) = f(b)(w, i)$ for all j included in i (i.e. all subintervals of i).
   c) For any predicate constant R_n, $f(R_n)(w, j)$ is included in $f(R_n)(w, i)$ for all subintervals j of i.

The valuations space for an IQ-structure consists of three truth values : 1 (*true*), 0 (*false*) and u (*undefined*). A formula will be assigned the value u whenever any of its non-logical constants are undefined.

Now for the *truth definition* for Liq. It proceeds in terms of the notion of an IQ-*interpretation* based on an IQ-structure M, depicted in (9):

(9) An IQ-interpretation is a pair $\langle M, g\rangle$ such that M is an IQ-structure and g[3] is a function which assigns values to the variables of Liq.

Given an IQ-interpretation, the denotation of a well-formed expression β is defined recursively. We let $[\![\beta]\!]^{\langle M,g\rangle}(w,i)$ be the denotation of β relative to the IQ-interpretation $\langle M, g\rangle$ with respect to the pair $(w,i) \in W \times I$. $[\![\beta]\!]^{\langle M,g\rangle}$ is defined recursively as follows:

1. Where β is a variable, $[\![\beta]\!]^{\langle M,g\rangle}(w,i) = g(\beta)$.

2. Where β is either a name constant or a predicate constant, $[\![\beta]\!]^{\langle M,g\rangle}(w,i) = f(\beta)(w,i)$.

3. Where β is a parameter, $[\![\beta]\!]^{\langle M,g\rangle}(w,i) = g_c(\beta)$.

4. Where β is an atomic wff $P^n(d_1,...,d_n)$, $[\![\beta]\!]^{\langle M,g\rangle}(w,i) =$
   1 if $\langle [\![d_1]\!]^{\langle M,g\rangle}(w,i),...,[\![d_n]\!]^{\langle M,g\rangle}(w,i)\rangle \in [\![P^n]\!]^{\langle M,g\rangle}(w,i)$,
   0 if $\langle [\![d_1]\!]^{\langle M,g\rangle}(w,i),...,[\![d_n]\!]^{\langle M,g\rangle}(w,i)\rangle \notin [\![P^n]\!]^{\langle M,g\rangle}(w,i)$,
   u if $[\![d_i]\!]^{\langle M,g\rangle}(w,i)$ is undefined for any i where $1 \leq i \leq n$ or $[\![P^n]\!]^{\langle M,g\rangle}(w,i)$ is undefined.

5. Where β is a wff $\neg A$, $[\![\beta]\!]^{\langle M,g\rangle}(w,i) =$
   1 if $[\![A]\!]^{\langle M,g\rangle}(w,i) = 0$,
   0 if $[\![A]\!]^{\langle M,g\rangle}(w,i) = 1$,
   u otherwise.

6. Where β is a wff $A \wedge B$[4], $[\![\beta]\!]^{\langle M,g\rangle}(w,i) =$
   1 if $[\![A]\!]^{\langle M,g\rangle}(w,i) = 1$ and $[\![B]\!]^{\langle M,g\rangle}(w,i) = 1$,
   0 if $[\![A]\!]^{\langle M,g\rangle}(w,i) = 0$ or $[\![B]\!]^{\langle M,g\rangle}(w,i) = 0$,
   u otherwise.

7. Where β is a wff $\exists xA$ with the individual variable x, $[\![\beta]\!]^{\langle M,g\rangle}(w,i) =$
   1 if $[\![A]\!]^{\langle M,g(x,e)\rangle}(w,i) = 1$ for some $e \in D$[5],
   0 if $[\![A]\!]^{\langle M,g(x,e)\rangle}(w,i) = 0$ for all $e \in D$,
   u otherwise.

8. Where β is a wff $\forall xA$ with the individual variable x, $[\![\beta]\!]^{\langle M,g\rangle}(w,i) =$
   1 if $[\![A]\!]^{\langle M,g(x,e)\rangle}(w,i) = 1$ for all $e \in D$,
   0 if $[\![A]\!]^{\langle M,g(x,e)\rangle}(w,i) = 0$ for some $e \in D$,
   u otherwise.

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[3] g is not to be confused with the indexical function g_c. g assigns denotations to the variables of Liq in an IQ-interpretation, whereas g_c assigns denotations to parameters in an IQ-structure.

[4] We will not give the truth definitions of the remaining three binary connectives for the sake of clarity. They are defined as in ordinary predicate logic.

[5] $g(x,e)$ is the same as g save that $g(x,e)(x) = e$, i.e. all occurrences of the individual variable x in A are replaced by e.

9. Where β is a wff $PRES_{(v,t)}(A)$ with $v \in P_W$ and $t \in P_I$, $[\![\beta]\!]^{\langle M,g\rangle}(w,i) =$
   1 if $[\![v]\!]^{\langle M,g\rangle} = w$ and $[\![t]\!]^{\langle M,g\rangle} = i$ and $[\![A]\!]^{\langle M,g\rangle}(w,i) = 1$,
   0 if $[\![v]\!]^{\langle M,g\rangle}$, $[\![t]\!]^{\langle M,g\rangle}$ defined but $[\![v]\!]^{\langle M,g\rangle} \neq w$ or $[\![t]\!]^{\langle M,g\rangle} \neq i$ or $[\![A]\!]^{\langle M,g\rangle}(w,i) = 0$,
   u otherwise.
   Where β is a wff $PAST_{(v,t)}(A)$ with $v \in P_W$ and $t \in P_I$, $[\![\beta]\!]^{\langle M,g\rangle}(w,i) =$
   1 if $[\![v]\!]^{\langle M,g\rangle} = w$ and $[\![t]\!]^{\langle M,g\rangle} = i$ and $[\![A]\!]^{\langle M,g\rangle}(w,j) = 1$ for some j such that $j \ll i$,
   0 if $[\![v]\!]^{\langle M,g\rangle}$, $[\![t]\!]^{\langle M,g\rangle}$ defined but $[\![v]\!]^{\langle M,g\rangle} \neq w$ or $[\![t]\!]^{\langle M,g\rangle} \neq i$ or $[\![A]\!]^{\langle M,g\rangle}(w,j) = 0$ for all j such that $j \ll i$,
   u otherwise.
   Where β is a wff $FUT_{(v,t)}(A)$ with $v \in P_W$ and $t \in P_I$, $[\![\beta]\!]^{\langle M,g\rangle}(w,i) =$
   1 if $[\![v]\!]^{\langle M,g\rangle} = w$ and $[\![t]\!]^{\langle M,g\rangle} = i$ and $[\![A]\!]^{\langle M,g\rangle}(w,j) = 1$ for some j such that $i \ll j$,
   0 if $[\![v]\!]^{\langle M,g\rangle}$, $[\![t]\!]^{\langle M,g\rangle}$ defined but $[\![v]\!]^{\langle M,g\rangle} \neq w$ or $[\![t]\!]^{\langle M,g\rangle} \neq i$ or $[\![A]\!]^{\langle M,g\rangle}(w,j) = 0$ for all j such that $i \ll j$,
   u otherwise.

The above truth definition 4 for atomic wff together with the homogeneity restrictions 4a, 4b and 4c on f yields the homogeneity principle (7), repeated below:

(7) An atomic formula or a boolean combination of atomic formulae is true at an index (w,i) only if for all subintervals j of i it is true at (w,j).

After these inevitable definitions of the syntax and semantics of Liq, the following section will focus on how one might formulate in Liq Vendler's classification of aspectual classes. But before that, let us proceed to an example of a derivation of an Liq formula.

3.5 An Example IQ Derivation

In order to fill the above definitions of the syntax and semantics of IQ with some more life, we will derive the truth conditions for an IQ representation of sentence (10), given in (10a):

(10) Max loved a woman

(10a) $PAST_{(v,t)}(\exists x(woman(x) \wedge love(max,x)))$

Now let us determine the truth conditions for (10a) under an IQ-interpretation $\langle M,g\rangle$ at a world-time index (w,i):

$[\![PAST_{(v,t)}(\exists x(woman(x) \wedge love(max,x)))]\!]^{\langle M,g\rangle}(w,i) = 1$ iff
$[\![v]\!]^{\langle M,g\rangle} = w$ and $[\![t]\!]^{\langle M,g\rangle} = i$ and there is an interval $j \ll i$ such that $[\![\exists x(woman(x) \wedge love(max,x))]\!]^{\langle M,g\rangle}(w,j) = 1$.

$[\![\exists x(woman(x) \wedge love(max,x))]\!]^{\langle M,g\rangle}(w,j) = 1$ iff
there is at least one $e \in D$ such that $[\![(woman(e) \wedge love(max,e)]\!]^{\langle M,g\rangle}(w,j) = 1$.

$[\![(woman(e) \wedge love(max, e)]\!]^{\langle M,g \rangle}(w, j) = 1$ iff
$[\![woman(e)]\!]^{\langle M,g \rangle}(w, j) = 1$ and $[\![love(max, e)]\!]^{\langle M,g \rangle}(w, j) = 1$.
$[\![woman(e)]\!]^{\langle M,g \rangle}(w, j) = 1$ iff
$[\![e]\!]^{\langle M,g \rangle}(w, j) \in [\![woman]\!]^{\langle M,g \rangle}(w, j)$
$[\![love(max, e)]\!]^{\langle M,g \rangle}(w, j) = 1$ iff
$\langle [\![max]\!]^{\langle M,g \rangle}(w, j), [\![e]\!]^{\langle M,g \rangle}(w, j) \rangle \in [\![love]\!]^{\langle M,g \rangle}(w, j)$

Put into words, the truth conditions of (10a) require that both there is a woman in M and the individual *max* stands in the relation *love* to this individual. So far, so unsurprising. New in the derivation above, compared with ordinary predicate logic, is that the truth conditions of (10a) additionally depend on the possible world w and the interval of time j. j must be earlier than i by the semantics of $PAST_{(v,t)}(A)$, since the latter includes the condition $j \ll i$. Hence i is taken as the time of utterance, and, because of the past tense, j must be an interval earlier than this time of utterance. What is also new is that the values of the parameters v and t, subscripting the $PAST$-operator, are determined by the indexical function g_c: $g_c(v)$ must denote the possible world w, and $g_c(t)$ the interval i.

After this small example of a derivation of an IQ formula we will proceed in formulating a Vendler-like classification of aspect in IQ.

4 The Formulation of a Classification of Aspect in IQ

Lascarides' aim is to capture the distinctions between Vendler's (1967) four aspectual classes semantically, and that amounts to providing an appropriate IQ model structure. To this end, she divides the set F of propositions into four classes:

- S, a set of state propositions, corresponding to Vendler's *states*
- Pr, a set of process propositions (Vendler: *activities*)
- E, a set of event propositions, comprising both Vendler's *accomplishments* and *achievements*.
- Φ, a set containing the remaining functions in F.

In order to distinguish between the members of S, Pr and E, Lascarides places conditions on each of these classes, which are described below. The condition on Φ is displayed in (11), for the sake of completeness:

(11) *Condition on* Φ
$\phi \in \Phi$ if and only if none of the conditions on S, Pr or E hold.

The set of functions Φ does not correspond to any aspectual category, but is included as a subclass of F since F shall contain *all* functions from $W \times I$ to $\{0, 1, u\}$.

4.1 State Propositions

Now for the conditions placed upon the other propositions from F. We begin with S, the set of state propositions.

(12) *Condition on S*
$s \in S$ if and only if for all $(w, i) \in W \times I$, if $s(w, i) = 1$ and if for all intervals j such that i is contained in j $s(w, j) = 0$, then i is open.

(12) captures the idea that states essentially extend in time but do not have definite endpoints. This is expressed by making any proposition $s \in S$ denote an *open interval* structure: Although s may be true on a closed interval, any such interval is surrounded by an open interval at which s is also true. Figure 2 depicts a temporal structure for an example state proposition[6].

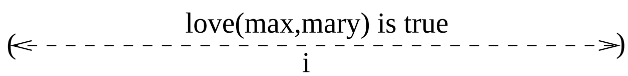

Figure 2: Example open interval structure of the state proposition $love(max, mary)$

4.2 Process Propositions

In classifying the set Pr of process propositions, Lascarides follows the idea that processes have definite start- and endpoints but not a culmination:

(13) *Condition on Pr*
$pr \in Pr$ if and only if for all indices $(w, i) \in W \times I$, if $pr(w, i) = 1$ and if for all intervals j such that i is contained in j, $pr(w, j) = 0$, then i is a closed non-minimal interval.

All $pr \in Pr$ denote a *closed interval* structure: Although pr may be true on an open interval, any such interval is surrounded by a closed interval at which pr is true. This is illustrated in figure 3.

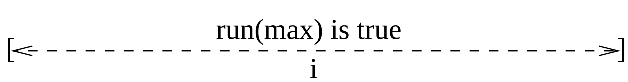

Figure 3: Example closed interval structure of the process proposition $run(max)$

So the formal characterization of state and process propositions have not posed any difficulties; propositions from S denote open intervals, capturing the notion that states have no definite start- and endpoints, and propositions from Pr denote closed intervals, expressing that processes do have definite start- and endpoints. What remains to be done is to characterize propositions from E, the set of events.

[6]Square brackets stand for closed, round ones for open intervals respectively in all the graphical representations of temporal structures shown.

4.3 Event Propositions

Lascarides' condition on event propositions constrains members of E to *minimal intervals* (singleton sets in IQ), i.e. to points of time:

(14) *Condition on E*
$e \in E$ if and only if for all $(w, i) \in W \times I$ such that $e(w, i) = 1$, i is a *minimal interval.*

The point of time at which event propositions may be true are to be thought as the culmination point of the event (i.e. when Max crosses the finish line to win the race). So Lascarides' characterization seems to be appropriate for the treatment of Vendler's achievements, which we said do not necessarily invoke a process prior to the culmination point. But (14) does not seem to be a suitable formalization of propositions from Vendler's class of accomplishments, which are also included in the set E of event propositions. Vendler (1967) characterized accomplishments (e.g. "Max built a house") as a process that leads to a culmination, and the notion of a prior process is completely absent from Lascarides' characterization of events.

Responsible for Lascarides' choice to characterize event propositions as points of time is the homogeneity principle of IQ. If an event proposition could become true also at a non-minimal interval i, however small, such an event would by homogeneity be forced to return true at all subintervals of i, and this would mean that the culmination of the event would occur at every interval contained in i, which is a highly undesirable consequence.

But how can Lascarides' characterization of events capture the intuition that events do involve a preparatory process prior to the culmination point, if not in (14), the condition she imposed on event propositions? As the attentive reader might have guessed, she makes use of the second leading idea in IQ besides the homogeneity principle: The representation of extra-linguistic context by *parameters*.

4.4 The Preparatory Process of an Event

In Lascarides' opinion, the preparatory process of an event proposition cannot be determined independently of extra-linguistic context. Therefore, she represents the process sense of an event proposition A as $PR_p(A)$ (where PR_p is a complex sentential operator), and hence "Max build a house" as in (15):

(15) $PR_p(build(max, house))$

According to Lascarides, a possible preparatory process for "Max build a house" might be that Max spends money on building materials with the intention of building a house. If this is the case, (15) is considered to be true. But there is an infinite number of other conceivable processes which result in the house being finished: In another context, Max could ask Peter to buy the building materials, or Maria, or he could be the owner of a DIY-store so that he would not even have to buy the materials, and still build a house.

As mentioned before, IQ's *parameters* are used by Lascarides to achieve an interpretation of (15) which incorporates the notion of extra-linguistic context. The parameter p subscripting the sentential operator PR_p is a referring expression that refers to a process proposition, and the latter is identified by extra-linguistic context. The process proposition is assigned to p by the indexical function g_c. In our building house example (15), $g_c(p)$ could be $[\![spend(max, money, building\_materials)]\!]$ in some context — the process that Max spends money on building materials.

But how does Lascarides ensure in her semantic definition of the preparatory process of an event that e.g. $[\![spend(max, money, building\_materials)]\!]$ really does constitute the prior process to (15) in some context? The latter process might be totally unrelated to the culmination point in that Max spends money on building materials just for fun, with no intention whatsoever to build a house. For this reason, Lascarides stipulates a relation R (shown in (16) below) to associate the prior process of an event and its culmination. R is a temporal precedence relation: Whenever an event occurs, the preparatory process that leads to its culmination point must have been going on just before.

(16) If an event sentence A is true at (w, i), then there is some interval j such that i is the final bound of j and $PR_p(A)$ is true at (w, j).

Note that R expresses a *necessary* relation between A and $PR_p(A)$, since it must hold for every world-time index. Figure 4 shows a typical event structure (including its preparatory process).

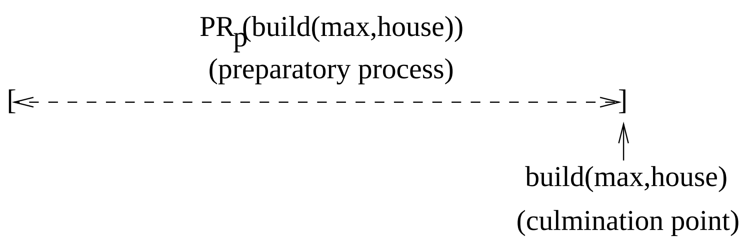

Figure 4: An event structure (preparatory process plus culmination point)

4.5 The Truth Conditions of PR_p

The truth conditions of PR_p incorporate both the import of extra-linguistic context and the temporal precedence relation R. They are exhibited in (17):

(17) $PR_p(A)$ is true with respect to $\langle M, g\rangle$ at (w, i) if

1. the proposition denoted by A (which we refer to as $[\![A]\!]^{\langle M,g\rangle}$) is a member of E, and $g_c(p)$ is a member of Pr, and
2. for all indices $(w', i') \in W \times I$, if $[\![A]\!]^{\langle M,g\rangle}(w', i') = 1$ then there is an interval j' whose final bound is i' and $g_c(p)(w', j') = 1$, and
3. $g_c(p)(w, i) = 1$;

it is false if either conditions 1, 2 or 3 do not hold; and otherwise it is undefined

We will now discuss the conditions in the truth definition of $PR_p(A)$ in some more detail.

Condition 1 constrains A to be a member of E, the set of event propositions, and $g_c(p)$ to be a member of Pr, the set of process propositions.

Condition 2 states the temporal precedence relation R between the event proposition A and the process proposition $g_c(p)$: Whenever A occurs, p must have occured just before. The effect of condition 2 is to semantically restrict the possible choices for $g_c(p)$ to reflect the intuition that the truth of A must be the result of the process $g_c(p)$ that was going on just beforehand.

Finally, condition 3 constrains $PR_p(A)$ to be only true if $g_c(p)(w,i) = 1$. Hence although $PR_p(A)$ is defined in terms of, among other things, the sentence A, the truth of $PR_p(A)$ does not entail the truth of A at any time. Only $g_c(p)$ must be true at (w,i) for $PR_p(A)$ to be true, so A may well be false at the same time. This reflects the intuition that the preparatory process of A may go on without the culmination is ever reached. In our building house example, an earthquake could utterly destroy Max's house just before it is finished to make the conclusion $build(max, house)$ false. The ability to formulate this intuition in IQ will prove very important when it comes to solving the imperfective paradox within the space of the following section.

5 A Solution to the Imperfective Paradox

The preceding section dealt with Lascarides' semantic characterization of Vendler's aspectual classes in the language of IQ (Richards et al. 1989). The aim of this section will be to build on this formalization by defining the semantics of the progressive. Then, having both an appropriate semantic characterization of the aspectual classes and the progressive at hand, Lascarides can formulate rather elegantly a solution to the imperfective paradox.

5.1 Characterizing the Progressive

In her semantic characterization the progressive, Lascarides follows Moens in that the progressive requires a process as input, and outputs a state describing the process as being in progress. To capture this intuition, Lascarides introduces into her theory the new operator $PROG$. $PROG(A)$ encapsulates the process sentence A, resulting in $PROG(A)$ denoting a state proposition. It asserts that the process A began at some earlier time than A and has not yet stopped. This is the truth definition of $PROG(A)$:

(18) $PROG(A)$ is true with respect to $\langle M, g\rangle$ at (w,i) if and only if $[\![A]\!]^{\langle M,g\rangle} \in Pr$ and there exists a closed interval j such that i is a proper subinterval of j and A is true at (w,j); it is false at (w,i) if either $[\![A]\!]^{\langle M,g\rangle}$ is not a member of Pr, or there is no closed interval j such that i is a proper subinterval of j and A is true at (w,j); and otherwise it is undefined.

The truth definition displayed in (18) captures Moens' idea that the progressive takes a process as its input in that it becomes false if A does not denote a proposition from Pr. In addition, it outputs a state proposition, since $PROG(A)$ is true only at *open* interiors of the largest connected intervals at which A itself is true. This makes $PROG(A)$ satisfy the condition on the members of S stipulated in (12) before.

That was how Lascarides' logically represents the progressive. On to her solution to the imperfective paradox then.

5.2 A Solution to the Imperfective Paradox

As already stated in the introduction, asolution to the imperfective paradox must be able to explain the entailment from sentence (1) to sentence (2), and simultaneously explain why there is no entailment from (3) to (4).

(1) Max was running

(2) Max ran

(3) Max was building a house

(4) Max built a house

Let us have a look at how Lascarides represents the process sentences (1) and (2) in IQ:

(1a) $PAST_{(v,t)}[PROG(run(max))]$

(2a) $PAST_{(v,t)}(run(max))$

We must now show that the truth of (1a) in a model M at an index (w, i) entails the truth of (2a) in M at (w, i). In other words, we must show that the progressive form of the process sentence (1) entails its corresponding non-progressive form (2). Before we start, we will repeat the definition of the tense operator $PAST_{(v,t)}$:

(8) $PAST_{(v,t)}(A)$ is true at the world-time index (w, i) if and only if $g_c(v) = w$, $g_c(t) = i$ and there exists an interval j earlier than i (i.e. $j \ll i$) such that A is true at (w, j).

Now suppose that (1a) is true in a model M at (w, i). Then following the truth conditions for the operator $PAST_{(v,t)}$, $g_c(v) = w$, $g_c(t) = i$, and $PROG(run(max))$ is true at an index (w, j), where $j \ll i$.

Following the truth definition of $PROG(A)$, $[\![run(max)]\!]^{\langle M,g\rangle} \in Pr$, and there exists a closed interval k such that j is a proper subinterval of k and $run(max)$ is true at (w, k).

Now the adoption of the homogeneous strategy in IQ becomes crucial. By the homogeneity principle of IQ, if $run(max)$ is true at (w, k), then it is also true at (w, j), since j is a proper subinterval of k. This means that $run(max)$ is true at (w, j), where $j \ll i$, which equals exactly the truth conditions of (2a). Therefore if (1a) is true in a model M at (w, i), (2a) cannot become false and is thus always also true in M at (w, i), which means that (1) entails (2), as required.

The second demand on a solution to the imperfective paradox in a formal semantic framework is that it must block the entailment from sentence (3) to sentence (4). To this end, we shall at first have a look at the logical forms Lascarides assigns to these sentences.

(3a) $PAST_{(v,t)}[PROG[PR_p(build(max, house))]]$

(4a) $PAST_{(v,t)}(build(max, house))$

The reader might wonder why the logical form of the progressive sentence (3), "Max was building a house", is not (3b) instead of (3a):

(3b) $PAST_{(v,t)}[PROG(build(max, house))]$

To see why, it suffices to look at the truth conditions for $PROG(A)$: A must be a *process* from Pr, and thus (3b) would always be false, because the input for $PROG$ in (3b) is not a process but the event proposition $build(max, house)$. Hence the complex operator PR_p serves in (3a) to bring out from the event $build(max, house)$ its preparatory process, in order to be able to apply the $PROG$-operator.

We will now show that Lascarides' theory blocks the entailment from (3) to (4). This will be done by constructing a model M such that (3a) is true in M at (w, i), and (4a) false in M, also at (w, i):

Suppose that (3a) is true in a model M at an index (w, i). This is the case (following the definition of $PAST(A)$), if and only if $g_c(v) = w$ and $g_c(t) = i$, and there exists an interval $j \ll i$ such that $PROG[PR_p(build(max, house))]$ is true at (w, j).

This is the case (definition of $PROG(A)$) if and only if $PR_p(build(max, house))$ denotes a process proposition, and there exists a closed interval k such that j is a proper subinterval of k and $PR_p(build(max, house))$ is true at (w, k).

This is the case if and only if (definition of $PR_p(A)$, given in (17) above):

1. $[\![build(max, house)]\!]^{\langle M,g \rangle} \in E$ and $g_c(p) \in Pr$,
2. for all indices $(w', i') \in W \times I$, if $build(max, house)$ is true at (w', i'), then there is an interval j' such that i' is the final bound of j' and $g_c(p)$ is true at (w', j'), and
3. $g_c(p)$ is true at (w, k).

Now as we said before when we stated the truth conditions of $PR_p(A)$, the truth of $g_c(p)$ with respect to $\langle M, g \rangle$ at (w, k) does not entail the truth of $build(max, house)$ at (w, k). Hence we can easily construct a model in which $build(max, house)$ is false at all times in w, or at least at all times $j \ll i$. Then (4a), the logical form of (4) is also false. This results in the logical form of (3) not entailing the logical form of (4), which is as required, and together with the proof that (1) does entail (2) shows that Lascarides' semantic theory solves the imperfective paradox.

6 Conclusion

Within the space of this article, we investigated Alex Lascarides' (in Lascarides 1988, Lascarides 1991) formulation of a solution to the imperfective paradox. The first task that Lascarides tackled was to represent a semantic distinction between sentences like (2) and sentences like (4):

(2) Max ran

(4) Max built a house

This distinction was formulated on the ground of Vendler's (1967) classification of aspectual classes (exhibited in section 2).

The second task necessary to tackle for a solution to the imperfective paradox was to build on the formalization of Vendler's aspectual categories by providing a formal characterization of the progressive which was sensitive to this distinction.

Lascarides solved both tasks in the interval-based semantic framework IQ by Richards et al. (1989) (explicated in section 3 and 4). Her choice fell on IQ because of two central properties of IQ, setting it apart from other interval-based frameworks. The first of these was the *homogeneity principle*, which later played a crucial role in explaining the entailment from (1) to (2):

(1) Max was running

(2) Max ran

The second important feature of IQ applied in Lascarides' analysis were *parameters* to capture the intuition that extra-linguistic context must determine exactly what process an utterance like "Max was building a house" denotes in a particular context.

With the help of these two essential properties of IQ, Lascarides offered a semantic account of the entailment from (1) to (2), and at the same time showed why there is no entailment from (3) to (4).

(3) Max was building a house

(4) Max built a house

That is, Lascarides solved the imperfective paradox.

Lascarides' aim was to formulate a *principled solution* to the imperfective paradox, i.e. a solution which also accounts for other aspectual phenomena such as the interaction of the progressive with universal quantification. To read about how her theory accounts for the interaction of the progressive with universal quantification or how point adverbials can be seamlessly integrated into the framework, we recommend (Lascarides 1988).

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