A Formal Definition of Temporal Default Relations

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In this paper, I will redefine standard formulations of aspect, using partial ordering structures (i.e., lattices) on intervals. I will show that such a reformulation allows unexpected insights on the nature of aspectual relations, and temporal relations more in general. More specifically, it will be shown that the underspecification account of unmarked aspect can be motivated in this way, and that the old idea of the present tense as a default tense (cf. Jakobson 1932/1971) can be formalized in a precise way. Furthermore, perfective and imperfective aspect turn out to be in a scalar relation, where imperfective aspect is more informative than perfective aspect.

1. The Problem of Unmarked Aspect

Until recently, most formal accounts of aspectual phenomena in tense-aspect systems of natural languages didn't feel a need to distinguish between the notions of *Aktionsart*-modifiers (like *begin to*) and view-point aspects (i.e., the aspectual properties associated with tenses like French *passé simple*, for instance), considering both of them as being essentially identical. From a type-theoretical point of view, these aspectual operators in a broad sense are supposed to be of type $\langle\langle e,t\rangle,\langle e,t\rangle\rangle$, that is, functions whose domain and range are sets of eventualities.[1] Such a proposal is expressed, among others, by de Swart (1998).

However, scholars like Smith (1991) and Klein (1994, 1995) have insisted to separate the more 'grammatical' *view-point aspect*, from more 'lexical' *Aktionsarten*-modifiers.[2] More precisely, Klein (1994) takes TENSE to be the relation between the time of utterance (TU) and the interval of assertion (T-Ast), whereas (view-point) ASPECT is the relation between the interval of assertion and the temporal trace of the eventuality (written here $\tau(e)$). Thus, according to this view, TENSE and (view-point) ASPECT are relations between intervals. But *Aktionsarten*-modifiers are relations between sets of eventualities.

[1] I use throughout this paper the following logical types: t stands for the type of truth-values, e for the type of eventualities, and i for the type of intervals (which may be points in time, that is, instants).

[2] In fact, this is a rediscovery of a theoretical distinction going back at least to Agrell (1908).

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From a type-theoretic point of view, TENSE is of type $\langle\langle i,t\rangle,\langle i,t\rangle\rangle$, (view-point) ASPECT of type $\langle\langle e,t\rangle,\langle i,t\rangle\rangle$, and *Aktionsarten*-modifiers are of type $\langle\langle e,t\rangle,\langle e,t\rangle\rangle$. Whereas TENSE and ASPECT are obligatory and non-recursive relations, *Aktionsarten*-modifiers may be present zero, one or more times (cf. Laca 2005).

As a consequence, each sentence in any language has got exactly one TENSE– and exactly one ASPECT-feature. There are no such restrictions on the occurrence of *Aktionsart*-modifiers.

1.1. Perfectives and Imperfectives

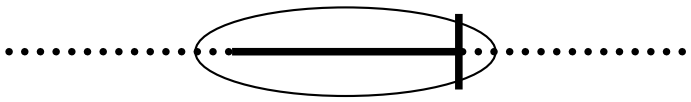
The neo-Reichenbachian frameworks of Smith (1991) and Klein (1994) provide a successful way of dealing with tenses expressing perfective and imperfective aspect. According to Smith, perfective aspect is associated with sequential readings (cf. the example in like (1a)), while imperfective aspect is associated with incidental readings (cf. (1b)):

(1) a. When John arrived, Mary sang a song. [perfective aspect in main clause]
b. When John arrived, Mary was singing a song. [imperfective aspect in main clause]

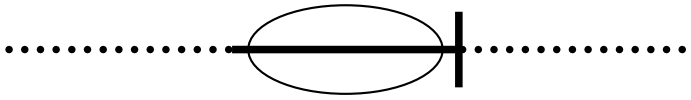
(1a) is interpreted as follows: the eventuality `sing(m)` starts after the eventuality of `arrive(j)` happened, and probably because of the occurring of the latter eventuality (this is referred to as the 'sequential reading'). (1b) does not allow for such a reading: the eventuality `sing(m)` must already have started, and still be ongoing, as the eventuality `arrive(j)` occurs (this is the 'incidental reading').

Smith (1991) characterizes perfective and imperfective aspect by a visual metaphor: aspect provides a 'lens' through which we perceive an eventuality. Perfective aspect allows us to 'see' the entire eventuality, while imperfective aspect 'hides' away from our vision the initial and end points of the eventuality, so that we cannot know if they actually took place. This is depicted in (2): the continuous, horizontal line stands for the temporal trace of the eventuality; the continuous vertical line marks the final transition of a (telic) eventuality. The dotted parts stand for initial and subsequent stages of an eventuality. The ellipsis delimits the region which is made 'visible' by perfective (in (2a)) and imperfective aspect (in (2b)), respectively:

(2) a.



b.



Similarly, according to Klein (1994), aspect is all about the speakers commitment to the existence of certain phases of the eventuality: perfective aspect means that the interval for which the speaker makes an assertion (the so-called *interval of assertion* or T-Ast) includes the temporal trace of the eventuality. In case of imperfective aspect, the interval of assertion is included in the temporal trace of the eventuality. Therefore, in the latter case, the commitment of the speaker is

restricted to inner stages of an eventuality, and excludes crucially the final transition.[3]

This has lead to the following formal representations of perfective and imperfective aspect:[4]

(3) a. $[\![\text{perfective}]\!] = \lambda P \lambda i \exists e[\tau(e) \subseteq i \wedge P(e)]$
b. $[\![\text{imperfective}]\!] = \lambda P \lambda i \exists e[i \subseteq \tau(e) \wedge P(e)]$

The formalizations in (3) are fairly standard in the sense that they are straightforward implementations of the views of Smith and Klein. However, they are incomplete: we know at least since Dowty (1979) that a reasonable account of imperfective aspect will have to include intensional (i.e., modal) semantics. However, (3b) is strictly extensional, which means that we will not be able to account for the so-called 'imperfective paradox'.[5] But as (3) captures straightforwardly the interval-part of the denotation of such aspects — which is what I am interested in — I will not be concerned here about this shortcoming. In the rest of the article, I will consider view-point aspect as relation between two intervals, and my only concern will be the formalization of the precise nature of this temporal relation.

Both Smith and Klein require thus the presence of an ASPECT-feature in any sentence. This raises an important issue: what is to be done with languages (like modern German or modern Hebrew) in which there is no opposition between two types of view-point aspect? In much of traditional work, ASPECT seemed to be a phenomenon worth of investigation only if it was involved in such aspectual oppositions, like perfective vs. imperfective in Slavonic languages, or the simple vs. progressive opposition in English.

I will address this problem now.

1.2. Dealing with Unmarked Aspect

Smith (1991) was the first author to propose a general treatment of aspectually unmarked tenses. She supposed that the aspectual behaviour of such tenses was the same across languages and across positions in the tense-aspect systems of particular languages: that is, (i) aspectually unmarked past tenses behave like aspectually unmarked future tenses; and (ii) aspectually unmarked tenses in Mandarin Chinese or Navajo behave like aspectually unmarked tenses in French or German. Smith showed that such tenses where ambiguous between a perfective-like sequential reading and an imperfective-like incidental reading in sentences containing a *when*-clause. The following two examples illustrate the point for the German *present perfect* and the

[3] Klein's notion of an assertion on phases of the eventuality is clearly a more proper way of speaking about the semantic properties of aspect than Smith's optical metaphor. However, the metaphor often provides a shorter way of saying things. Therefore, I will often say that such aspect x makes visible a certain phase y of the eventuality, which is a shortcut for the following: by using that aspect x, the speaker makes an assertion which is restricted to a certain phase y of the eventuality.

[4] Such a representation can be found, for instance, in Pancheva (2003:282).

[5] The paradox is that the formulas in (3) predict that the sentence below entails the existence of a (completed) event of building a house:

John was building a house [when he was struck by lightning and died].

However, nothing requires here that John actually finishes building the house.

simple *present* tenses:

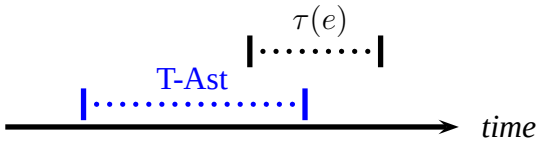
(4) a. Als Hans angekommen ist, hat Maria ein Lied gesungen.
when H. arrived is, has M. a song sung.
(i) 'When Hans arrived, Maria sang a song.'
(ii) 'When Hans arrived, Maria was singing a song.'

b. (Jedesmal) Wenn Hans ankommt, singt Maria ein Lied.[6]
(each time) when H. arrives, sings M. a song.
(i) 'Each time when Hans arrives, Maria sings a song.'
(ii) 'Each time when Hans arrives, Maria is singing a song.'

One sees that in both cases, the verb in the main clause may get the aspectual interpretation either of a perfective, or of an imperfective. However, they do not allow for just any temporal ordering of the two eventualities: `sing(m)` may not be properly anterior to `arrive(h)`. According to Smith, this behavior is the same in all aspectually unmarked tenses she investigated.

Based on this empirical observation, Smith claims that there is one single type of viewpoint aspect, namely *neutral* aspect, which is able to explain the aspectual behavior of such aspectually unmarked tenses. This aspectual view-point has been characterized by the formula (5a), which is represented graphically in (5b):[7]

(5) a. $[\![\text{neutral}]\!] = \lambda P \lambda i \exists e[i \fallingdotseq \tau(e) \wedge P(e)]$
where $i \fallingdotseq i' \Leftrightarrow i \cap i' \neq \emptyset \wedge \exists t[t \in i \wedge t \notin i' \wedge \forall t'[t' \in i' \rightarrow t \prec t']]$

b. 

However, the formalisation in (5) is not able to capture all readings we need. First of all, if the aspectual properties of the verb in the main clause is the determining ingredient for sequential or incidental readings in contexts like (1) or (4), the difference must stem from the fact that with perfective aspect, the initial point of the eventuality is visible. Therefore, we get an inchoative reading. With imperfective aspect, the initial point is not visible, and we will have an ongoing construal. But with the formula in (5a), the initial point of the eventuality under neutral viewpoint aspect is always visible. Therefore, we should get systematically sequential readings, and never any incidental readings.

One might argue that the relative temporal ordering of the eventualities in contexts of sentences containing a *when*-clause is not directly influenced by the aspectual properties of the verb in the main clause. It might be that rhetorical relations govern these orders, and that aspect

[6] A sentence like (4b), without the quantifier *each time*, would also have a futurate reading, and a reading one might qualify as 'modal' (if Hans arrives, there will be an event `sing(m)`). However, the relative temporal ordering in all of these readings may be sequential or incidental.

[7] The definition in (5) is taken from Pancheva (2003:282). This is not exactly the same definition as the one suggested by Smith, because Pancheva requires at least one subinterval of T-Ast to be situated before $\tau(e)$. However, both definitions will produce the same problems, because the initial point of the eventuality is always visible.

only gives some indication which rhetorical relation applies, without determining directly the relative temporal orders. SDRT-approaches to tense and aspect emphasize such relations (cf. Asher & Lascarides 2003). If their analysis is on the right track, the contexts used by Smith in order to identify aspectually unmarked tenses would not be very telling. But other contexts should allow us then to identify the exact characteristics of the view-point of aspectually unmarked tenses.

One context I would like to insist on as being particularly revealing for the aspectual properties of tenses are sentences containing *since*-adverbials. Notice first, that, if the notion of an interval of assertion has any descriptive value, that interval needs to cover in sentences like (6) the time-span from midday up to the time of speech. Second, remember that the German *present perfect* and the simple *present* tenses are aspectually unmarked in the sense of Smith (1991), as we have seen in the examples (4).

(6) a. Hans isst seit Mittag einen Apfel.
H. eats since midday an apple.
'Hans has been eating an apple since midday.'
b. Hans hat seit Mittag einen Apfel gegessen.
H. has since midday an apple eaten.
'Hans has eaten one apple since midday.'

(6a) is to be interpreted as follows: Hans has spent the whole period from midday up to the moment of speech eating an apple, and he is still eating it. This corresponds to an imperfective view-point, as the temporal trace of the eventuality needs to be at least as long as the interval of assertion. (6b) is to interpreted perfectively: the event of eating an apple is properly included in the interval of assertion, and crucially, it is no longer on-going at the moment of speech. Therefore, aspectually neutral tenses do allow for clear-cut imperfective, as well as clear-cut perfective construals of the temporal trace of the eventuality with respect to the interval of assertion.[8] However, a single view-point is not able to allow for such a behavior. As far as I know, the only theory compatible with clear-cut imperfective and perfective readings of aspectually unmarked tenses is the underspecification approach by Reyle et al. (2005).

According to such an underspecification approach, every aspectually unmarked tense is simultaneously perfective and imperfective. Discourse-update will decide if one of the two aspectual readings has to be eliminated.

There are, of course, some issues with such an underspecification approach, amongst others, a big potential for overgeneration. However, for the remainder of the paper, I will not be concerned with this problem. The only point I will discuss is the following: why should we underspecify between perfective and imperfective aspect, rather than, say, resultative and prospective

[8]Notice that the fact of the *present perfect* being a *perfect* does not change things: even if PERFECT denoted something like a proper or large precedence of $\tau(e)$ with respect to T-Ast (cf. the formulæ below), this would not explain the perfective reading of (6b); it predicts a 'perfect'-reading, according to which the post-state of eating fills up the whole interval of assertion. I leave it to the reader to check this.

a. $[\![\text{perfect}_1]\!] = \lambda P \lambda i \exists e[\tau(e) \prec i]$
b. $[\![\text{perfect}_2]\!] = \lambda P \lambda i \exists e[\tau(e) \preceq i]$

aspect?[9] Empirical adequacy is certainly one important point, but explanatory force is another. And unmotivated underspecification clearly lacks explanatory force.

In the remainder of the paper, I will show what it is that makes imperfective and perfective aspect privileged relations among all the possible temporal relations, and how aspectual underspecification — but also the idea of the present tense being a zero-tense — can be motivated.

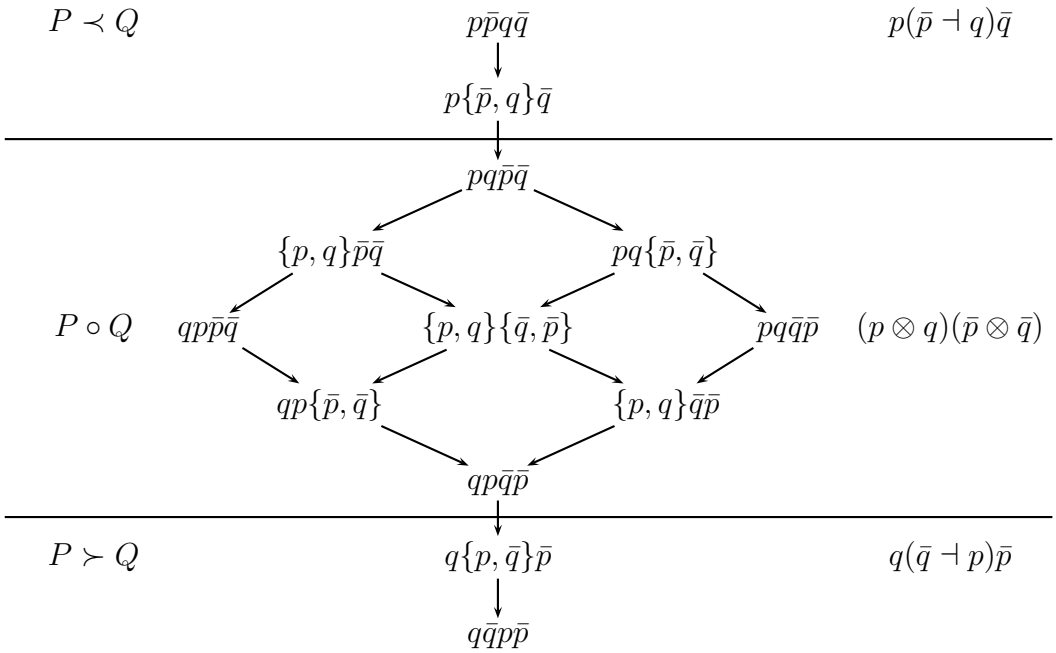
2. Partial Orders on Intervals

Partial orders have been used extensively and for quite some time in order to model event-structures, beginning with Bach (1986). To some degree, such analyses are competing with the neo-Reichenbachian approach in modelizations of aspectual properties of natural languages (cf. Krifka 1992, 1998; de Swart 1998). Surprisingly, there has not been much interest in modelizing intervals or time-structures in partial orders, maybe because of the standard model of time as a totally ordered structure. However, even if (the set of instants of) time is totally ordered, intervals clearly are not. To the best of my knowledge, Schwer in Battistelli et al. (2006) is the first to have modeled intervals in a lattice-structure.

Battistelli et al. (2006) show, following Allen (1984), that there are thirteen possible relations between two intervals, non of which is a point. While Allen has simply listed all the possibilities, the lattice by Battistelli et al. allows to see how the possibilities are interrelated, and that there are indeed no other possible temporal configurations.

The thirteen possible relations between intervals are organized as follows:

(7)



where x is the beginning point of interval X, $\bar{x}$ is the endpoint of X; xy means that x is

[9] Following Klein, I assume aspect to be a relation between two intervals, namely the interval of assertion and the temporal trace of the eventuality. We will see in the next section that there are thirteen theoretically possible relations, if instants are excluded from the temporal ontology.

located before y; $\{x, y\}$ means that x and y coincide.

In the left column, we find the temporal ordering of the two intervals in a DRT-notation: either one of the two intervals precedes the other, or they overlap. The rightmost column shows the notation in Schwer's S-language which allows to generate the combinations in the central column (cf. Schwer 2002).

In order to get a feeling for the notation, let us follow the leftmost path from the highest node to the bottom node of the lattice. The first combination we find is $p\bar{p}q\bar{q}$. This means that the whole interval P — starting with p and ending with $\bar{p}$ — is situated before the interval Q — starting with q and ending with $\bar{q}$. As $\bar{p}$ is situated at the left of q, this means that $\bar{p}$ is anterior to p, and therefore, P and Q have no point in common.

The next position we come across is $p\{\bar{p}, q\}\bar{q}$. Here, the end-point of P and the beginning point of Q coincide; the two intervals 'touch', but without overlapping. Going down one more node, we find ourselves at $pq\bar{p}\bar{q}$. Here, for the first time, P and Q overlap. At the next step, q moves further right, and coincides with p, then precedes p still one node further, at $qp\bar{p}\bar{q}$. Now, P is included in Q. Then, $\bar{p}$ first coincides with, then follows $\bar{q}$. These are the last two cases of overlap on our path. Finally, P and Q separate again, first, $\bar{q}$ and p coincide, to end up with $\bar{q}$ being situated before p. Thus, at the bottom of the diagram, Q is completely anterior to P.

The path we have gone down may be imagined as follows: first, the beginning point of Q, namely q, 'moves' further and further left, until being in first position. Then, the end-point of P, namely $\bar{p}$, will move further and further right, until being in last position. Finally, the initial point of P will also move to the right, until the two intervals are disjoint again.

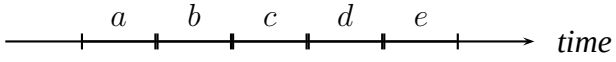
Now, perfective and imperfective aspect, according to the formulas I have given in (3), correspond to the three configurations in the middle-lign, namely $qp\bar{p}\bar{q}$, $\{p, q\}, \{\bar{p}, \bar{q}\}$ and $pq\bar{q}\bar{p}$. The fact that these configurations end up on a single lign might be a simple optical effect, or have some deeper meaning: Schwer's formalization does not provide us with a means to decide this.

So, the lattice by Schwer and the classification by Allen make the question even more intriguing: what makes perfective and imperfective view-point that special? In the next section, I will suggest an answer to this question: these two view-point aspects correspond to elementary subsets of partials orders on intervals: ideals and filters.

2.1. View-points, Ideals and Filters

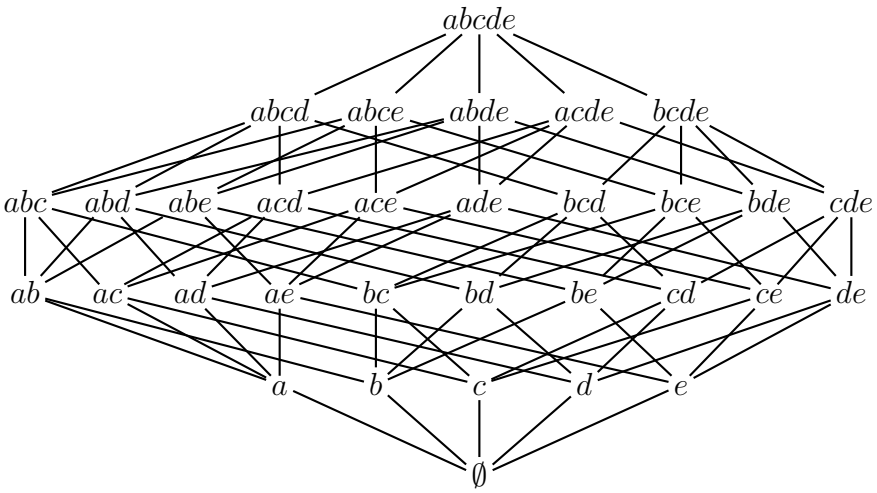
Bearing in mind the definitions of perfective and imperfective aspect from (3), we will establish the following minimal model: assume that there are five minimal temporal intervals a, b, c, d and e — ordered like illustrated in (8a), which together form the interval $abcde$:

(8) a. $a \prec b \prec c \prec d \prec e$

b. 

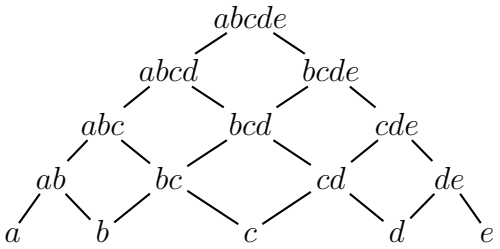
If we now establish blindly a lattice composed of these five minimal intervals, we will get the following:

(9)



For our purposes, (9) is not very useful. Notice that it contains many elements which are not intervals, that is, convex times. An interval is nothing but a set of times without 'holes'. Clearly, something like ac is not an interval, it rather is made of two disjoint intervals.[10] Then, there is no real need for the empty set at the bottom: one can quite safely assume that every eventuality has to occupy at least a minimal interval, or, put in an other way: every eventuality has a temporal trace, however short it may be. Therefore, we obtain the following semi-join-lattice, in which only intervals appear:

(10)



Now, let us suppose that our interval of assertion is bcd. Given the definitions in (3), the possible values of $\tau(e)$ under perfective (written $\tau(e)_P$) or imperfective ($\tau(e)_I$) aspect are the following:

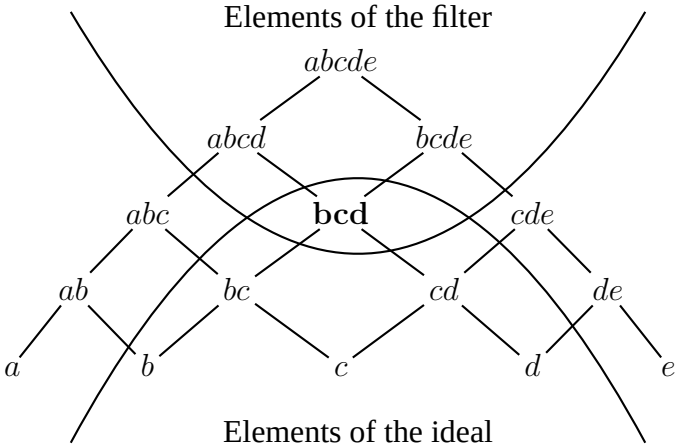
(11) a. Possible values of $\tau(e)_P$: $\{b, c, d, bc, cd, bcd\}$
b. Possible values of $\tau(e)_I$: $\{bcd, abcd, bcde, abcde\}$

These values are not just arbitrary subsets of the semi-join-lattice: they correspond to the ideal and the filter generated by bcd, that is, our interval of assertion.

(12) a. $(x] = \{y \in X : y \sqsubseteq x\}$, the ideal generated by x (the set of all parts y of x)[11]
b. $[x) = \{y \in X : x \sqsubseteq y\}$, the filter generated by x (the set of all elements y such that x is a part of y)

[10] ac has a 'hole', namely b.

c.



Perfective and imperfective aspect can therefore be redefined as follows:

(13) a. $[\![\text{perfective}]\!] = \tau(e) \in (\text{T-Ast}]$ [$\tau(e)$ = element of the ideal generated by T-Ast]

b. $[\![\text{imperfective}]\!] = \tau(e) \in [\text{T-Ast})$ [$\tau(e)$ = element of the filter generated by T-Ast]

Filters and ideals are very elementary subsets of partial orders. They have been used extensively to deal with the denotation of noun phrases, but also event-structures (cf. Landman 1991, 2000, 2004). As the anonymous reviewer of this paper pointed out, they are likely to be an essential underlying grammatical mechanism that applies to different components of grammar. Therefore, the fact that perfective and imperfective aspects correspond to those subsets provides an important motivation to single out these two view-points for the characterization of aspectually unmarked tenses, as proposed by Reyle et al. (2005) for the German present tense.

We may now give a formal definition of the default aspectual relation:

(14) $[\![\text{default aspect}]\!] = \tau(e) \in (\text{T-Ast}] \vee \tau(e) \in [\text{T-Ast})$

The unmarked view-point aspect corresponds therefore to the union of the filter and the ideal generated by the interval of assertion.

Notice that we have assumed so far an atomic semi-join-lattice for the sake of exposition. Note, however, that the definitions in (14) do not require us to assume an atomic lattice (and therefore, minimal temporal intervals): nothing rules out instants (i.e., temporal points) in our temporal ontology.

2.2. Generalizing to All Temporal Relations

We have developed so far a formalization of a default ASPECT-feature. Now, ASPECT is only one relation between intervals: we also have the TENSE-feature. Are there any default tense-relations as well? Indeed, Jakobson (1932/1971) — amongst others — argued that the (Russian)

[11] Definitions taken from Landman (2004), p. 3.

present tense is an instance of a default tense. Our definition provides indeed an easy way of generalizing what we have developed for the default ASPECT.

So, we can go a step further, generalize our idea to all temporal relations, and claim the following:

(15) An interval i is in a temporal default relation with respect to an interval i' iff i is an element of the filter or the ideal generated by i':
$i \circledcirc i' \Leftrightarrow i \in [i') \vee i \in (i']$

The definition in (15) allows to give a very precise formulation of the Jakobson's idea that the present tense is a default tense, and we can check that the PRESENT feature assumed in various neo-Reichenbachian approaches is indeed an instance of the temporal default relation:

(16) $[\![\text{present}]\!] = \lambda i.[n \subseteq i]$
where n is the moment of utterance

If one assumes that the moment of utterance is always a point (or a minimal interval), (16) turns out to be a temporal default relation, because T-Ast $\subseteq$ TU reduces under this assumption to T-Ast $=$ TU, which is a special case of (16). Therefore, (16) is an instance of a temporal default relation.

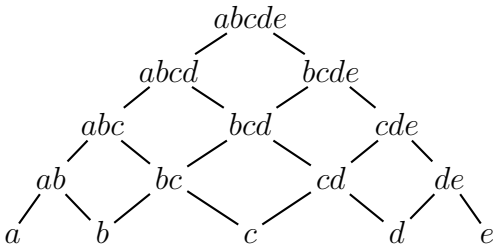
Let us now investigate the properties of the temporal default relation. One can show that it is reflexive, symmetric, but not transitive:

(17) a. Reflexivity: $\forall i[i \circledcirc i]$
b. Symmetry: $\forall i, i'[i \circledcirc i' \rightarrow i' \circledcirc i]$
c. Non-Transitivity: it is not the case that $\forall i, i', i''[i \circledcirc i' \wedge i' \circledcirc i'' \rightarrow i \circledcirc i'']$

(17a) states that each interval is in a temporal default relation with itself; (17b) that, if an interval is in a default relation with another interval, the other interval will itself stand in a default relation with the first interval. These points are obvious.

(17c) may be less obvious at first sight, but we can check it easily considering our minimal model in (10) (repeated below): the intervals b and bcd are in a temporal default relation; so are bcd and d. However, b and d clearly fail to be in a temporal default relation.

(10)



The property of non-transitivity of the temporal default relation has one important consequence: we cannot simply drop one temporal relation, and expect the system to be as expressive as with two temporal relations. Assume that c is our moment of utterance, and that we have got one single temporal default relation. Then, we may reach by this any element of the filter generated

by c, but a, b, d and e are out of range. Assume now that we have got two temporal default relations. We may now attain any element of the lattice: c is in a temporal default relation with the supremum (the supremum being an element of the filter generated by c), and any single interval is an element of the ideal generated by the supremum.

So, even if all temporal relations involved in a given tense (which might be the case of German or French simple present tenses), you may not simply drop one of the two relations: that means, both TENSE and ASPECT will remain obligatory. Given our original commitment to neo-Reichenbachian tense-aspect semantics, this is a welcome feature of the analysis.

2.3. Further Consequences and Possible Applications of this Analysis

The notion and precise definition of a temporal default relation may be useful for approaches dealing with the grammaticalisation of a tense-aspect form. It is often supposed that the grammaticalisation of a form corresponds to a 'rise' of that form in the functional structure of a sentence. For instance, the following process concerning the grammaticalisation of resultative forms to perfects seems to be cross-linguistically very frequent (cf. Meillet 1909/1982; Roberts & Roussou 2003):

(18) a. resultatives *become*
b. perfects *become*
c. past tenses

When is it possible for a form to rise? One may assume that this is the case only if the target position has not been already occupied. But what does it mean to for a functional projection to be 'empty'? In the temporal domain, one may assume that 'emptyness' corresponds to the temporal default relation. The process described in (18) could therefore be formalized as in (19):[12]

(19) a. TU $\circledcirc$ P, P $\circledcirc$ T-Ast, T-Ast $\succ \tau(e)$ [Resultative present] *becomes*
b. TU $\circledcirc$ P, P $\succ$ T-Ast, [Present perfect] *becomes*
c. TU $\succ$ P, [Past]

In (19), no non-default relation blocks the rise of the temporal relation '$\succ$'. Therefore, it can rise into the TENSE-position. Consider what happens with a *pluperfect*:

(20) a. TU $\succ$ P, P $\circledcirc$ T-Ast, T-Ast $\succ \tau(e)$ [Resultative past] *becomes*
b. TU $\succ$ P, P $\succ$ T-Ast, [Past perfect] *cannot become*
c. TU $\succ$ P, [Past]

The TENSE-position in (20) is already occupied by a non-default relation, namely '$\succ$': therefore, a *pluperfect* is predicted not to able to become a past tense, because the TENSE-position is already occupied.

[12] P is the point of perspective, introduced by Kamp & Reyle (1993). In Schaden (2007), I have argued for the necessity of integrating such a point P into a framework in the style of Klein (1994).

A rather unexpected consequence of the analysis advocated here is that we can show that imperfective and perfective aspect are situated on a Horn-scale, where the imperfective aspect is the strong member of the pair:

(21) perfective $<$ imperfective

Horn-scales (cf. Horn 1989) are scales of asymmetrical entailment, and are often used to explain the pragmatic inferences some quantifiers give rise to:

(22) some $<$ all
  a. Mary has eaten some apples.
  b. Mary has eaten all apples.

(22b) entails (22a), but (22a) does not entail (22b). Therefore, (22b) is said to *entail asymmetrically* (22a). Such scales are used in pragmatics to explain why sentences like (22a) are interpreted generally as *Mary has eaten some apples, but not all apples*, although this is not the truth-conditional content of such a sentence.[13] The argument goes roughly as follows: if the speaker of (22a) would have known (22b) to be true, he would have violated the Gricean maxim of quantity ("say as much as you can") in uttering (22a). Therefore, the speaker either does not know whether (22b) is true, or he knows that (22b) is false. In this way, we have explained why we get the inference.

A somewhat similar phenomenon in the tense-aspect system has been known for quite some time: sentences with perfective aspect entails asymmetrically the corresponding sentences with imperfective aspect:

(23) a. John drew a circle.
  b. John was drawing a circle.

(23a) asymmetrically entails (23b), and therefore we should expect the perfective to be strong member of the pair, and not the imperfective. So, how could it be possible that imperfective aspect could ever in a general way asymmetrically entail perfective aspect, like I have claimed in (21)?

The reasoning goes as follows: on the level of the aspectual projection, imperfective aspect does entail perfective aspect, because in any way, by the definition in (13), the interval denoted by $\tau(e)$ under perfective aspect (written $\tau(e)_P$) will always be included in the interval denoted by $\tau(e)$ under imperfective aspect (written $\tau(e)_I$). More generally, it is provably the case that any element of the ideal generated by the interval of assertion will be included in any element of the filter generated by that same interval:

(24) a. $\tau(e)_P \sqsubseteq \tau(e)_I$, since:
  b. $\forall x, y, z[x \in [z) \wedge y \in (z] \rightarrow y \sqsubseteq x]$[14]

[13] This can be shown as follows:

> Mary has eaten some apples; in fact, she ate all of them.

The continuation should be infelicitous if the meaning of *some* were *some, but not all*.

Thus, choosing imperfective view-point aspect amounts for the speaker to asserting something for a longer period of time, and is therefore more informative (at the level of the ASPECT-feature) than perfective aspect.

It is easy to see why this Horn-scale on the rather abstract level of the ASPECT-feature does not carry over readily to cases like (23): in order to affect the sentence as a whole, the properties of the eventuality under perfective and imperfective aspect must be comparable. This means crucially that the eventuality must have the subinterval property, which is not the case in (23). Additionally, the interval of assertion must be stable between two sentences in order to maintain the scalar relationship. There is not guarantee either for this in (23).

These are quite restrictive conditions, but if they are respected, we do indeed get the entailment from imperfective to perfective sentences. Consider (25):

(25) John has been in Boston since Friday.

If the notion of interval of assertion has any descriptive content, it must apply in (25) to the interval starting at Friday, and lasting up to the moment of speech. Now, (25) has got an existential and a universal reading. Under the existential reading, John must have spent at least some subinterval of the relevant period in Boston. This is a perfective reading (because $\tau(e) \subseteq$ T-Ast). Under the universal reading, John must have spent the whole period in Boston, and must still be in Boston at the moment of speech. This is an imperfective reading (because T-Ast $\subseteq \tau(e)$). Notice that here, where T-Ast is fixed by *since Friday*, and where `be_in_Boston` has the subinterval property, the imperfective (universal) reading indeed does entail the perfective (existential) reading.[15]

The discovery of the scalar relation between imperfective and perfective may lead to insights concerning the aspectual behavior of some focus particles, like German *gerade* or Romanian *tocmai*, which, when applied to aspectually unmarked tenses, yield imperfective or progressive readings (cf. Schaden 2007):

(26) a. Als das Feuer ausbrach, setzte Otto seinen Helm auf.
when the fire outbroke, put Otto his helmet on.
(i) 'When the fire broke out, Otto put on his helmet.'
(ii) 'When the fire broke out, Otto was putting on his helmet.'

b. Als das Feuer ausbrach, setzte Otto gerade seinen Helm auf.
when the fire outbroke, put Otto GERADE his helmet on.
(i) *'When the fire broke out, Otto put on his helmet.'
(ii) 'When the fire broke out, Otto was putting on his helmet.'

The aspectually unmarked *Präteritum* may have a perfective or an imperfective reading (although the perfective reading is much more salient in (26a)). However, when applying *gerade* to the main clause, only the imperfective reading subsists. I have argued in Schaden (2007) that

[14]Proof (by contradiction) of (24b): Assume that there are x, y, z such that $x \in [z)$ and that $y \in (z]$, but that $y \not\sqsubseteq x$. But if $x \in [z)$, then $z \sqsubseteq x$ (by definition of the filter), and if $y \in (z]$, then $y \sqsubseteq z$ (by definition of the ideal). But if $y \sqsubseteq z$ and $z \sqsubseteq x$, then $y \sqsubseteq x$ (by transitivity of the partial order). Therefore, we have got a contradiction with the premise.

[15]This has already been noticed by Mittwoch (1988).

this behavior of *gerade* can be explained if one assumes that *gerade* applies to the ASPECT-feature, and that it discards the less informative perfective reading, while retaining the more informative imperfective reading.

3. Conclusion and Perspectives

In this paper, I have shown that standard formalisations of imperfective and perfective aspect can be redefined in a way that provides some insights about the configuration of the tense-aspect system of natural languages. Specifically, the proposed redefinition on partial orders of intervals allows to define a general notion of temporal default relations. It motivates aspectual underspecification approaches, and unveils the scalar relation between perfective and imperfective aspects.

Since events can be (and have been) analysed in lattice-structures, the definitions of perfective and imperfective aspect proposed in this paper could probably be used to investigate whether there exists a homomorphism between theories of aspect using eventuality modification as theoretic tool (like Filip (2000)), for instance), and theories advocating a view-point aspect in the sense of Smith (1991). These two schools of thought might very well turn out to be notational variants, and equivalent concerning the empirical predictions they produce.

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