

# Temporal reasoning with aspectual adverbials

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## Abstract

This paper<sup>1</sup> presents an analysis of dynamic temporal reasoning with Dutch adverbials of aspectual focus. The crucial property of focus constructions is the inherent opposition between the actual value for a given parameter and the possible alternatives in the speaker's expectation. The dynamic perspective tries to account for the fact that when new information is added, certain components are updated, whereas other components remain constant across information states. However, both the focus dimension and the dynamic dimension presuppose a more elementary step in the analysis, namely that of aspectual continuity and that of static temporal reasoning.

## 1. Introduction

The four italicised forms in (1) are standardly assumed to constitute the core paradigm of aspectual adverbials:

- (1) a. Jan was toen *nog niet* aan het lezen.  
John was then still not PROG read  
'John was *not* reading *yet* at that moment.'
- b. Jan was toen *al* aan het lezen.  
John was then already PROG read  
'John was *already* reading at that moment.'
- c. Jan was toen *nog* aan het lezen.  
John was then still PROG read  
'John was *still* reading at that moment.'
- d. Jan was toen *niet meer* aan het lezen.  
John was then not anymore PROG read  
'John was *not* reading *any more/longer* at that moment.'

Various labels have been used in the literature to refer to these four elements : *perspectivity particles* (Van Baar,1990; Vandeweghe,1992), *particles of change and continuation* (Van Baar,1991; Van der Auwera,1991a,b), *phasal adverbials* (Löbner,1989/1990; Van der Auwera, 1998) or *phasal polarity items* (Van Baar, 1997). In Smessaert (1997, 1998, 1999) it is argued that *nog niet* in (1a), *nog* in (1c) and *niet meer* in (1d) constitute an independent paradigm of CONTINUITY expressions which *al* in (1b) does not belong to. Although the position taken in this paper is somewhat less radical, *al* is nevertheless viewed as the key to two different paradigms of four adverbials, the first of which is given in (2) :

- (2) a. Jan was toen *nog altijd niet* aan het lezen.  
John was then still always not PROG read

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- 'John was *still not* reading at that moment.'
- b. Jan was toen *al* aan het lezen.  
John was then already PROG read  
'John was *already* reading at that moment.'
- c. Jan was toen *nog altijd* aan het lezen.  
John was then still always PROG read  
'John was *STILL* reading at that moment.'
- d. Jan was toen *al niet meer* aan het lezen.  
John was then already not anymore PROG read  
'? John was *not* reading *any more/longer* at that moment *already*.'

First of all, both the adverbials in (1) and those in (2) are **ASPECTUAL**: they explicitly refer to the internal structure of the situation or event that is described. The adverbials in (1a-b) and (2a-b) refer to the **BEGINNING** of the *reading*-event, whereas those in (1c-d) and (2c-d) refer to the **END** of the *reading*-event. The forms in (2), however, also belong to the realm of **FOCUS**. The key property of focus constructions in general is that actual values for a given parameter are explicitly opposed to possible alternative values (see e.g. König, 1991:32ff). In the case of **ASPECTUAL FOCUS** the **ACTUAL** location of the temporal reference point with respect to a given stage in the course of events is inherently opposed to **POSSIBLE ALTERNATIVE** locations. With *al* in (2b) and *al niet meer* in (2d) the actual course of events is evaluated as **FASTER** than expected. With *nog altijd niet* in (2a) and *nog altijd* in (2c), by contrast, the actual course of events is evaluated as **SLOWER** than expected. This sense of discrepancy or tension between reality and expectation is lacking with *nog niet* in (1a), with *nog* in (1c) and with *niet meer* in (1d).

Notice, by the way, that Dutch and English, which are generally considered to be fairly closely related to one another, differ considerably in the way they lexicalize aspectual focus. English does not readily allow adverbial clusters such as *still always* in (2a) and (2c) or *already no longer* in (2d). Instead it has to resort to lexical distinctions such as that between *not yet* in (1a) and *still not* in (2a), or to the mechanism which imposes focus structures by means of emphatic intonation patterns, as with *STILL* in (2c). Often, however, as in (2d) for instance, it turns out to be very hard to provide proper English equivalents for the aspectual focus constructions in Dutch. This is even more obvious in (3), which presents the second paradigm of aspectual focus in which *al* plays a role :

- (3) a. Jan was toen *al bijna* aan het lezen.  
John was then already almost PROG read  
'?? John was *almost* reading at that moment *already*.'
- b. Jan was toen *eindelijk* aan het lezen.  
John was then finally PROG read  
'John was *finally* reading at that moment.'
- c. Jan was toen *al bijna niet meer* aan het lezen.  
John was then already almost not anymore PROG read  
'?? John was *almost no longer* reading at that moment.'
- d. Jan was toen *eindelijk niet meer* aan het lezen.  
John was then finally not anymore PROG read  
'? John was *finally not* reading *any more/longer* at that moment.'

With *al bijna* in (3a) and *al bijna niet meer* in (3c), two adverbial combinations without any direct English counterparts, the actual course of events is again faster than expected, whereas with *eindelijk* in (3b) and *eindelijk niet meer* in (3d) it is slower than expected.

Although there is a fundamental similarity between the mechanism of focus on the one hand and that of comparison and quantification on the other, the two should not be conflated in connection

with aspectuality. As is described in Smessaert (1999, chapter 4), the eight adverbials of aspectual focus in the two paradigms in (2) and (3) are complemented by eight adverbials of aspectual quantification whose function is to evaluate the distance between the temporal reference point and the transition of beginning or ending as being short or long. With a temporal reference point that is located before the beginning of an event, for instance, the two focus adverbials *nog altijd niet* ('still not') in (2a) and *al bijna* ('almost already') in (3a) have quantificational counterparts in the form of *nog lang niet* (still long not, 'not yet by far') and *nog net niet* (still just not, 'not yet but about to'). These adverbials of aspectual quantification will not be dealt with in this paper, however.

The central aim is to account for valid and invalid reasoning patterns involving adverbials of focus and involving the dynamic flow of time. Consider the inference pattern in (4), where  $t_1$ ,  $t_2$  and  $t_3$  are linearly ordered temporal reference points, and where the (a) and (b) sentence correspond to the major and the minor premiss respectively, the (c) sentence is a valid conclusion, whereas the (c') sentence is an invalid conclusion (henceforth indicated by means of the asterisk):

- (4) a. Jan was om  $t_1$  *nog altijd niet* aan het slapen.  
John was at  $t_1$  still always not PROG sleep.  
'John was *still not* asleep at  $t_1$ .'
- b. Jan viel om  $t_2$  in slaap.  
John fell at  $t_2$  in sleep.  
'John fell asleep at  $t_2$ .'
- c. Jan was om  $t_3$  *eindelijk* aan het slapen.  
John was at  $t_3$  finally PROG sleep.  
'John was *finally* asleep at  $t_3$ .'
- c'. \*Jan was om  $t_3$  *al* aan het slapen.  
\*John was at  $t_3$  already PROG sleep.  
'\*John was *already* asleep at  $t_3$ .'

Within a framework of dynamic semantics the contribution of the minor premiss in (4b) can be defined in terms of the changes it triggers in the information state described in the major premiss in (4a): some of the information will be updated, whereas other information remains stable across information states. The difference between the valid conclusion in (4c) and the invalid one in (4c') is then due to the fact that in the former case the original focus information ('slower than expected') is preserved in the new information state, whereas in the latter case it is not.

In order to capture the various informational dimensions involved in this type of reasoning patterns a bit-string formalism is proposed which generalizes the basic distinction between positive and negative polarity. The formalism is deliberately kept to a minimum so as to allow detailed implementation in different versions or frameworks of dynamic semantics, such as Discourse Representation Theory (Kamp & Reyle, 1993), File Change Semantics (Heim, 1983) or Dynamic Predicate Logic (Groenendijk & Stokhof, 1991).

In part one of the paper the adverbials of aspectual continuity in (1) are dealt with, whereas part two analyses the adverbials of aspectual focus in (2-3). Both parts have a parallel internal structure. First of all, a bit-string representation is introduced, which is three-dimensional in the continuity case but five-dimensional in the focus case. Secondly, these bit-strings are used to describe static temporal reasoning, that is inferences which concern one and the same information state. Thirdly, the bit-string formalism is shown to allow a straightforward account of dynamic temporal reasoning across different information states, as illustrated in (4).

## 2. Adverbials of aspectual continuity

### 2.1 The bitstring representation

Starting point of the analysis is the basic distinction between positive polarity in (5a) and negative polarity in (5b), which is labeled POLARITY DIMENSION A in (6):

- (5) a. Jan slaapt (John is asleep)  
 b. Jan slaapt *niet* (John is *not* asleep)

(6) **polarity dimension A: actual polarity**

- A = 1 *positive polarity:* property is currently true  
 A = 0 *negative polarity:* property is currently false

This dimension obviously plays a central role with the four adverbials of aspectual continuity in (1), here repeated as (7):

- (7) a. Jan slaapt *nog niet* (John is *not yet* asleep)  
 b. Jan slaapt *al* (John is *already* asleep)  
 c. Jan slaapt *nog* (John is *still* asleep)  
 d. Jan slaapt *niet meer* (John is *no longer* asleep)

With *al* in (7b) and *nog* in (7c) the actual polarity is positive (the temporal reference point T is located inside the sleeping-event) whereas with *nog niet* in (7a) and *niet meer* in (7d) the actual polarity is negative (with T being located before or after the sleeping-event respectively). However, these adverbials also involve two new polarity dimensions, namely B in (8) and C in (9):

(8) **polarity dimension B: event-internal polarity transition**

- B = 1 *beginning:* transition from negative to positive polarity  
 B = 0 *finishing:* transition from positive to negative polarity

(9) **polarity dimension C: speaker's perspective in describing the event**

- C = 1 *retrospective:* looking backward to an actual transition  
 C = 0 *prospective:* looking forward to a likely transition

The positive B-polarity of beginning holds for *nog niet* in (7a) and *al* in (7b), whereas the negative B-polarity of finishing holds for *nog* in (7c) and *niet meer* in (7d). The retrospective adverbials *al* in (7b) and *niet meer* in (7d) get positive C-polarity, whereas the prospective ones, namely *nog niet* in (7a) and *nog* in (7c) get negative C-polarity. The different polarity assignments are summarized in the three-dimensional polarity grid in (10):

(10)

THREE-DIMENSIONAL POLARITY GRID				
		A	B	C
(5a)	Jan slaapt (John is asleep)	1	-	-
(5b)	Jan slaapt <i>niet</i> (John is <i>not</i> asleep)	0	-	-
(7a)	Jan slaapt <i>nog niet</i> (John is <i>not yet</i> asleep)	0	1	0
(7b)	Jan slaapt <i>al</i> (John is <i>already</i> asleep)	1	1	1
(7c)	Jan slaapt <i>nog</i> (John is <i>still</i> asleep)	1	0	0
(7d)	Jan slaapt <i>niet meer</i> (John is <i>no longer</i> asleep)	0	0	1

Thus the component parts in the paraphrases of *not yet asleep* as *likely to start sleeping*, or in that of *no longer asleep* as *actually finished sleeping* can straightforwardly be associated with the three different polarity dimensions:

- (11) a. *nog niet slapen* (*not yet asleep*)                      b. *niet meer slapen* (*no longer asleep*)  
       likely                      (C=0)                                      actually                      (C=1)  
       to start sleeping      (B=1)                                      finished sleeping        (B=0)  
       but not sleeping     (A=0)                                      and hence not sleeping (A=0)

An important observation in connection with the polarity grid in (10) is that, although the interaction of three binary parameters yields eight logical possibilities ( $2^3$ ), only four of them actually show up. In other words, the assignment of a certain value to one parameter imposes constraints on the assignment of values to the others<sup>2</sup>. Referring to the bit-value combinations 11 and 00 as CONVERGENT, and to 10 and 01 as DIVERGENT, these co-occurrence restrictions can be formulated by means of the equivalences in (12-14):

- (12) [ (AB = convergent)  $\Leftrightarrow$  (C = 1) ]  $\wedge$  [ (AB = divergent)  $\Leftrightarrow$  (C = 0) ]  
 (13) [ (AC = convergent)  $\Leftrightarrow$  (B = 1) ]  $\wedge$  [ (AC = divergent)  $\Leftrightarrow$  (B = 0) ]  
 (14) [ (BC = convergent)  $\Leftrightarrow$  (A = 1) ]  $\wedge$  [ (BC = divergent)  $\Leftrightarrow$  (A = 0) ]

Although these equivalences reveal a certain redundancy in the three-dimensional polarity grid (in the sense that two binary parameters suffice to distinguish four expressions) it is not a configuration of primary versus secondary parameters<sup>3</sup>, but rather a matter of mutual predictability: given the value assignment of any combination of two parameters the value of the third parameter can be predicted.

## 2.2 Static temporal reasoning

The key advantage of representing the meaning of aspectual adverbials in terms of these bit-strings of polarity values is that it allows a straightforward and intuitively appealing account of temporal inferences. The first type, namely the static inferences, concern one and the same information state. The most trivial examples of these static inferences are given in (15) and (16):

- (15) a. Jan slaapt *al* om t1  $\rightarrow$  Jan slaapt om t1  
           (John is *already* asleep at t1  $\rightarrow$  John is asleep at t1)  
       b. Jan slaapt *nog* om t1  $\rightarrow$  Jan slaapt om t1  
           (John is *still* asleep at t1  $\rightarrow$  John is asleep at t1)  
 (16) a. Jan slaapt *nog niet* om t1  $\rightarrow$  Jan slaapt *niet* om t1  
           (John is *not yet* asleep at t1  $\rightarrow$  John is *not* asleep at t1)  
       b. Jan slaapt *niet meer* om t1  $\rightarrow$  Jan slaapt *niet* om t1  
           (John is *no longer* asleep at t1  $\rightarrow$  John is *not* asleep  
       at t1)

<sup>2</sup> The same observation is made by Löbner (1990:134-135) who also operates with three binary parameters A, B and C. However, his A-parameter corresponds to our C-parameter and vice versa. Furthermore, the values assigned to these parameters are related to the concept of markedness, with “-” standing for unmarked and “+” for marked. The result is a systematic reversal of the value assignments: our positive polarity (1) corresponds to his unmarked case (-), whereas our negative polarity (0) corresponds to his marked case (+).

<sup>3</sup> Löbner (1990:134-135) takes a radically different view: our C-parameter of retrospectivity versus prospectivity (his A-parameter) does not readily fit his markedness-perspective and is hence discarded with altogether. As the discussion of the focus adverbials in part two will reveal, however, the C-parameter is pivotal for the analysis proposed here (see also Vandeweghe, 1992:100ff).

The validity of these inferences depends on the preservation of the A-polarity. The sentences containing a continuity adverbial whose A-parameter has value 1, namely *al/already* (111) in (15a) and *nog/still* (100) in (15b), entail the positive polarity sentence without aspectual adverbial. Those having an adverbial with A-value 0, namely *nog niet/not yet* (010) in (16a) and *niet meer/no longer* (001) in (16b), entail the elementary negative polarity sentence.

A second type of static temporal reasoning relates to the concept of internal negation or subnegation of aspectual adverbials<sup>4</sup>. In Dutch there is a clear formal relation between the adverbials *nog* and *nog niet*. In terms of the bit-strings, the C-value is kept fixed as 0, but the A- and B-values are reversed, from 01(0) with *nog niet* to 10(0) with *nog*. This polarity reversal can be neutralized, however, if the original verbal predicate, such as *slapen* (*be asleep*) in (15-16) is simultaneously substituted by its contradictory predicate *wakker zijn* (*be awake*). This time the result is not a unidirectional entailment relation but an equivalence relation. Furthermore, this equivalence not only holds between *nog* and *nog niet* in (17) but also between *al* and *niet meer* in (18):

- (17) a. Jan slaapt *nog niet* om t1 ~ Jan is *nog* wakker om t1  
           (John is *not yet* asleep at t1 ~ John is *still* awake at t1)  
       b. Jan slaapt *nog* om t1 ~ Jan is *nog niet* wakker om t1  
           (John is *still* asleep at t1 ~ John is *not yet* awake at t1)
- (18) a. Jan slaapt *al* om t1 ~ Jan is *niet meer* wakker om t1  
           (John is *already* asleep at t1 ~ John is *no longer* awake at t1)  
       b. Jan slaapt *niet meer* om t1 ~ Jan is *al* wakker om t1  
           (John is *no longer* asleep at t1 ~ John is *already* awake at t1)

### 2.3 Dynamic temporal reasoning

The difference between static and dynamic temporal reasoning is that the latter crucially relies on the changes in information states associated with the transition from one temporal reference point to the next. The general pattern that will be used for this type of reasoning thus takes as its major premiss the description, by means of an aspectual adverbial, of a state holding at the first temporal reference point t1. As a second step the punctual verb in the minor premiss indicates that a polarity transition takes place at a subsequent temporal reference point t2. The conclusion then contains a different aspectual adverbial describing the resulting state at a third temporal reference point t3. Consider the inference pattern in (19):

- (19) a. Jan was om t1 *nog* aan het slapen.  
           ‘John was *still* asleep at t1.’  
       b. Jan werd om t2 wakker.  
           ‘John woke up at t2.’  
       c. Jan was om t3 *niet meer* aan het slapen.  
           ‘John was *no longer* asleep at t3.’

In order to account for the validity of (19) one needs to distinguish between those pieces of information which are modified or updated in going from one information state to the next, and those pieces which remain stable across information states. In terms of the bit-string representations the question is which parameters change their values going from *nog/still* in (19a) to *niet meer/no longer* in (19c). The contribution of the minor premiss in (19b), namely locating a polarity transition at

<sup>4</sup> This relation is crucial in the duality-framework of Löbner (1989,1990). His position that *al* (*already*) and *nog* (*still*) are one another’s dual, in the same way as the existential and universal quantifiers of predicate logic, has met with considerable criticism in Van der Auwera (1993), Mittwoch (1993), De Mey (1994) and Smessaert (1997).

t2, obviously corresponds to switching the C-value from 0 (i.e. prospectively looking towards a likely transition) to 1 (i.e. retrospectively looking back upon an actual transition). From the co-occurrence restrictions in (12-14) it can furthermore be inferred that as soon as the value for one parameter is reversed, the value of one (and only one) of the other two parameters needs to be reversed as well. In this case the reversal of the dynamic C-parameter correlates with that of the more static A-parameter for the actual polarity (or more informally: moving across a C-border entails ending up in a different A-territory). The value of the B-parameter, however, has to be kept constant. In other words, temporal reasoning can only concern one single polarity transition consisting of adjacent and opposite polarity areas. The temporal inference pattern in (19), whose validity relies on reversing the A- and C-values but preserving the B-value, is schematically represented in (20):

		A—B—C
(20) a.	<i>nog/still</i> asleep at t1	1 _0 _0
b.	wakker worden/wake up at t2	
c.	<i>niet meer/no longer</i> asleep at t3	0 _0 _1

The examples in (21) illustrate what happens when the other two logical possibilities of changing two values while keeping the third are used for temporal reasoning:

(21) a.	Jan was om t1 <i>nog niet</i> aan het slapen. 'John was <i>not yet</i> asleep at t1.'	-A B C 0 1 0
b.	Jan viel om t2 in slaap. 'John fell asleep at t2.'	
c.	*Jan was om t3 <i>nog</i> aan het slapen. *'John was <i>still</i> asleep at t3.'	1 0 0
c'.	*Jan was om t3 <i>niet meer</i> aan het slapen. *'John was <i>no longer</i> asleep at t3.'	0 0 1

Although in (21c) the A-value of the actual polarity is reversed with *nog/still* the prospectivity of the C-parameter is not changed accordingly. Instead, the B-transition of beginning is replaced by that of finishing, hence jumping forward too much inside the event for a valid inference. An even bigger jump forward occurs in (21c'): although the C-value is turned to retrospectivity, the actual polarity of the A-parameter does not follow, while the B-parameter is switched from beginning to finishing. As a consequence, two polarity transitions are crossed in one move, which results in an invalid inference pattern. The valid inferences on the basis of the two premisses in (21a-b), by contrast, are given in (22):

(22) a.	Jan was om t1 <i>nog niet</i> aan het slapen. 'John was <i>not yet</i> asleep at t1.'	A B C 0 1 0
b.	Jan viel om t2 in slaap. 'John fell asleep at t2.'	
c.	Jan was om t3 ( <i>?al</i> ) aan het slapen. 'John was ( <i>?already</i> ) asleep at t3.'	1 1 1
c'.	Jan was om t3 <i>niet meer</i> wakker. 'John was <i>no longer</i> awake at t3.'	0 0 1

Strictly speaking the inference in (22c) runs perfectly parallel to that in (19-20): the A- and C-values are reversed whereas the B-value remains constant. However, the question-marks with *al/already* reveal that the situation may not be as symmetric as suggested. Indeed, the focus dimension of *al/already*, which will be dealt with in full detail in the next part and which invokes the idea of FASTER THAN EXPECTED, somehow seems to interfere. This is not at all the case with (22c'). Here the dynamic reversal of the AC-values is followed by the static reversal of the AB-values in combi-

nation with the substitution of the contradictory predicate. In other words, switching the adverbial BC-values and negating the predicate yields a perfectly valid dynamic inference as the focus dimension plays no role with *niet meer/no longer*.

### 3. Adverbials of aspectual focus

#### 3.1 The bitstring representation

Within the three-dimensional polarity system presented in the previous part, the two adverbials in (23) would be assigned identical bit-strings, namely 010, and the same thing holds for the two adverbials in (24), which would both get 001:

- (23) a. Jan was toen *nog niet* aan het lezen.  
John was then still not PROG read  
'John was *not* reading *yet* at that moment.'
- b. Jan was toen *nog altijd niet* aan het lezen.  
John was then still always not PROG read  
'John was *still not* reading at that moment.'
- (24) a. Jan was toen *niet meer* aan het lezen.  
John was then not anymore PROG read  
'John was *not* reading *any more/longer* at that moment.'
- b. Jan was toen *al niet meer* aan het lezen.  
John was then already not anymore PROG read  
'? John was *not* reading *any more/longer* at that moment *already*.'

In other words, the extra focus dimension which distinguishes *nog altijd niet* in (23b) from *nog niet* in (23a), and which introduces the idea SLOWER THAN EXPECTED, cannot be represented in the three-way polarity system. Similarly, the focus idea FASTER THAN EXPECTED, which distinguishes *al niet meer* in (24b) from *niet meer* in (24a) remains unaccounted for. Therefore, two polarity dimensions are added to the system in (25) and (26), which both relate to the concept of "expected alternative":

(25) **polarity dimension D: evaluative focus**

- |       |                       |  |
|-------|-----------------------|--|
| D = 1 | <i>positive focus</i> | course of events is earlier/faster than expected |
| D = 0 | <i>negative focus</i> | course of events is later/slower than expected   |

(26) **polarity dimension E: counterfactuality of the expected alternative**

- |       |                        |   |
|-------|------------------------|---|
| E = 1 | <i>primary focus</i>   | expected polarity is opposite to the actual polarity  |
| E = 0 | <i>secondary focus</i> | expected polarity is identical to the actual polarity |

Thus, the meaning of the focus adverbials in (23b) and (24b) is captured in terms of a five-dimensional bit-string, whereas their continuity counterparts in (23a) and (24a) only get assigned a three-dimensional bit-string. The continuity and focus assignments are integrated in the table in (27):



(27)

FIVE-DIMENSIONAL POLARITY GRID		A	B	C	D	E
(5a)	Jan slaapt (John is asleep)	1	-	-	-	-
(5b)	Jan slaapt niet (John is <i>not</i> asleep)	0	-	-	-	-
(7a)	Jan slaapt <i>nog niet</i> (John is <i>not yet</i> asleep)	0	1	0	-	-
(7b)	Jan slaapt (?al) (John is <i>already</i> asleep)	1	1	1	-	-
(7c)	Jan slaapt <i>nog</i> (John is <i>still</i> asleep)	1	0	0	-	-
(7d)	Jan slaapt <i>niet meer</i> (John is <i>no longer</i> asleep)	0	0	1	-	-
(2a)	Jan slaapt <i>nog altijd niet</i> (John is <i>STILL (?always) not</i> asleep)	0	1	0	0	1
(3a)	Jan slaapt <i>al bijna</i> (?John is <i>already almost</i> asleep)	0	1	0	1	0
(2b)	Jan slaapt <i>al</i> (John is <i>already</i> asleep)	1	1	1	1	1
(3b)	Jan slaapt <i>eindelijk</i> (John is <i>finally</i> asleep)	1	1	1	0	0
(2c)	Jan slaapt <i>nog altijd</i> (John is <i>STILL (?always) asleep</i> )	1	0	0	0	1
(3c)	Jan slaapt <i>al bijna niet meer</i> (??John is <i>already almost no longer</i> sleep)	1	0	0	1	0
(2d)	Jan slaapt <i>al niet meer</i> (?John is <i>already no longer</i> asleep)	0	0	1	1	1
(3d)	Jan slaapt <i>eindelijk niet meer</i> (?John is <i>finally no longer</i> asleep)	0	0	1	0	0

In order to illustrate the bit-string assignments of 01010 for *al bijna (already almost)* and of 00100 for *eindelijk niet meer (finally no longer)* the paraphrases are decomposed in (28a-b):

(28) a. <i>al bijna</i> slapen ( <i>already almost</i> )	b. <i>eindelijk niet meer</i> slapen ( <i>finally no longer</i> )
not sleeping (A=0)	not sleeping (A=0)
start of sleeping (B=1)	end of sleeping (B=0)
likely in future (C=0)	actual in the past (C=1)
faster than expected (D=1)	slower than expected (D=0)
expecting not-P (E=0)	expecting not-P (E=0)

A first observation to be made in connection with the table in (27) is that the two focus parameters, namely D and E, are logically independent of one another: all four logical combinations of bit-values for DE -- i.e. 00, 01, 10 and 11 -- actually occur. If we combine the values for DE with that of the C-parameter, however, we notice that only four out of the eight logical CDE combinations are available.

Interestingly enough, the co-occurrence restrictions which were formulated in terms of convergent (11 or 00) versus divergent (01 or 10) bit-pairs in the analogous case with the ABC bit-strings in (12-14) can be applied here as well. Consider the equivalences in (29) to (31) :

$$(29) [(DE = \text{convergent}) \Leftrightarrow (C = 1)] \wedge [(DE = \text{divergent}) \Leftrightarrow (C = 0)]$$

$$(30) [(CE = \text{convergent}) \Leftrightarrow (D = 1)] \wedge [(CE = \text{divergent}) \Leftrightarrow (D = 0)]$$

$$(31) [(CD = \text{convergent}) \Leftrightarrow (E = 1)] \wedge [(CD = \text{divergent}) \Leftrightarrow (E = 0)]$$

The key equivalences here are undoubtedly those in (29) since they can be conflated with the ones in (12) above to yield the five-dimensional co-occurrence restrictions in (32):

$$(32) [(AB \text{ convergent}) \Leftrightarrow (C=1) \Leftrightarrow (DE \text{ convergent})] \wedge [(AB \text{ divergent}) \Leftrightarrow (C=0) \Leftrightarrow (DE \text{ divergent})]$$

In other words, the fact that only eight out of the thirty-two logical possibilities ( $2^5 = 32$ ) for a five-piece ABCDE bit-string are available in (27) can be seen as the result of multiplying the ABC-restrictions in (12) with the CDE-restrictions in (29). The pivotal role of the C-parameter of perspective (i.e. prospectivity versus retrospectivity) in formulating these restrictions will be confirmed by its role in accounting for dynamic temporal reasoning later on<sup>5</sup>. Although the equivalences in (32) reveal a certain redundancy in the five-dimensional polarity grid (in the sense that three binary parameters suffice to distinguish eight expressions) it is once again not a configuration of primary versus secondary parameters, but rather a matter of mutual predictability: given the value assignment of any combination of three parameters, other than ABC or CDE, the value of the fourth and fifth parameter can be pre-dicted.

### 3.2 Static temporal reasoning

As was already demonstrated with the continuity adverbials in the first part of the paper, the key advantage of the bit-string representation of the meaning of aspectual adverbials is that it allows a straightforward account of temporal inferences. With the static inferences, which concern one single information state, the most trivial examples are those whose validity depends on the preservation of the A-polarity. The examples given in (33) and (34) are the focus counterparts of the continuity inferences in (15) and (16) above:

- (33) a. Jan slaapt *al bijna niet meer* om t1 → Jan slaapt om t1  
 (John is *already almost no longer* asleep at t1 → John is asleep at t1)
- b. Jan slaapt *nog altijd* om t1 → Jan slaapt om t1  
 (John is *still (always)* asleep at t1 → John is asleep at t1)
- (34) a. Jan slaapt *nog altijd niet* om t1 → Jan slaapt *niet* om t1  
 (John is *still not* asleep at t1 → John is *not* asleep at t1)
- b. Jan slaapt *al niet meer* om t1 → Jan slaapt *niet* om t1  
 (John is *already no longer* asleep at t1 → John is *not* asleep at t1)

The sentences containing a focus adverbial whose A-parameter has value 1, such as *al bijna niet meer* (10010) in (33a) and *nog altijd* (10001) in (33b), entail the positive polarity sentence without aspectual adverbial. Those having an adverbial with A-value 0, such as *nog altijd niet* (01001) in (34a) and *al niet meer* (00111) in (34b), entail the elementary negative polarity sentence.

On a more informal level the original continuity inferences from ABC to A in (15-16) could also be paraphrased as “ignore the last two parameters but preserve everything else”. The same approach can be applied to the focus bit-strings: in addition to the inferences from ABCDE to A in (33-34), a second type of inferences takes one from ABCDE to ABC, i.e. from a focus adverbial to a continuity adverbial. In other words, ignoring the focus parameters DE but preserving the ABC values yields a valid inference, as is illustrated in (35) and (36) below:

<sup>5</sup> See footnote 3 for the radically different status of the C-parameter in Löbner (1990).

- (35) a. Jan slaapt *al bijna niet meer* om t1 → Jan slaapt *nog* om t1  
 (John is *already almost no longer* asleep at t1 → John is *still* asleep at t1)
- b. Jan slaapt *nog altijd* om t1 → Jan slaapt *nog* om t1  
 (John is *still (always)* asleep at t1 → John is *still* asleep at t1)
- (36) a. Jan slaapt *nog altijd niet* om t1 → Jan slaapt *nog niet* om t1  
 (John is *still not* asleep at t1 → John is *not yet* asleep at t1)
- b. Jan slaapt *al niet meer* om t1 → Jan slaapt *niet meer* om t1  
 (John is *already no longer* asleep at t1 → John is *no longer* asleep at t1)

Both with *al bijna niet meer* (35a) and *nog altijd* in (35b) the ABC values in the five-dimensional bit-string, namely 10010 and 10001 respectively, are preserved in going to the three-dimensional ABC-string of *nog*, namely 100. Similarly, the 010 assignment of *nog niet* in (36a) preserves the ABC values of *nog altijd niet*, i.e. 01001, whereas the 001 of *niet meer* preserves the ABC values in the 00111 assignment of *al niet meer*. As was pointed out in connection with (22c), the status of *al/already* as a three-dimensional continuity adverbial is problematic. This is confirmed by the inference in (37a), which is trivial, and that in (37b), which yields a focus conflict, although in both cases the ABC values of 111 are preserved:

- (37) a. Jan slaapt *al* om t1 → Jan slaapt (?*al*) om t1  
 (John is *already* asleep at t1 → John is (?*already*) asleep at t1)
- b. \* Jan slaapt *eindelijk* om t1 → Jan slaapt (?*al*) om t1  
 (\* John is *finally* asleep at t1 → John is (?*already*) asleep at t1)

In connection with (17-18) it was shown that the formal relation of internal negation between the continuity adverbials *nog* (100) and *nog niet* (010) for instance, which reverses the AB-values but keeps the C-value fixed, can be exploited for temporal reasoning: the AB-reversal can be neutralized by simultaneous substitution of the contradictory predicate, which results in an equivalence relation. As can be inferred from such pairs as *nog altijd* (10001) versus *nog altijd niet* (01001) or *al bijna* (01010) versus *al bijna niet meer* (10010) this mechanism of internal negation naturally extends to the domain of focus adverbials. In these cases the values for the AB parameters are switched but those for the CDE-parameters are preserved. Consider the equivalences in (38) and (39) where the predicate-substitution neutralizes the internal negation on the adverbials:

- (38) a. Jan slaapt *nog altijd niet* om t1 ↔ Jan is *nog altijd* wakker om t1  
 (John is *still not* asleep at t1 ↔ John is *still (always)* awake at t1)
- b. Jan slaapt *nog altijd* om t1 ↔ Jan is *nog altijd niet* wakker om t1  
 (John is *still (always)* asleep at t1 ↔ John is *still not* awake at t1)
- (39) a. Jan slaapt *al bijna* om t1 ↔ Jan is *al bijna niet meer* wakker om t1  
 (John is *already almost* asleep at t1 ↔ John is *already almost no longer* awake at t1)
- b. Jan slaapt *al bijna niet meer* om t1 ↔ Jan is *al bijna* wakker om t1  
 (John is *already almost no longer* asleep at t1 ↔ John is *already almost* awake at t1)

Since the equivalences based on internal negation can be defined both on the five-dimensional focus level in (38-39) and on the three-dimensional continuity level in (17-18) they can interact with the unidirectional entailment from focus to continuity in (35-36) in two different ways. This is demonstrated in (40) by means of the complex entailment from *already almost no longer awake* to *not yet asleep*:

- (40) Jan is *al bijna niet meer* wakker  
 (John is *already almost no longer* awake)  
 1 0 0 1 0

*reverse AB-polarity*  
*reverse predicate*

*preserve ABC-polarity*

- Jan is *al bijna* aan het slapen  
 (John is *already almost* asleep)  
 0 1 0 1 0

- Jan is *nog* wakker  
 (John is *still* awake)  
 1 0 0

*preserve ABC-polarity*

*reverse AB-polarity*  
*reverse predicate*

- Jan is *nog niet* aan het slapen  
 (John is *not yet* asleep)  
 0 1 0

On the left-hand track in (40) the equivalence precedes the entailment: the AB-values are first reversed on the five-dimensional level before the ABC-values are preserved stepping down to the three-dimensional level. Conversely, on the right-hand track in (40), the entailment precedes the equivalence: the step from focus to continuity, preserving the ABC-assignment, is taken before the AB-values are reversed on the three-dimensional level.

### 3.3 Dynamic temporal reasoning

With the dynamic approach to temporal reasoning the crucial question becomes which pieces of information are modified or updated in going from one information state to the next, and which pieces remain stable across information states. Consider the valid inference pattern in (41), where the major premiss contains a focus adverbial describing a state holding at t1, the minor premiss induces a polarity transition at a subsequent t2, and the conclusion describes the resulting state at t3 by means of a different focus adverbial:

- |         |   | A | B | C | D | E |
|---------|---|---|---|---|---|---|
| (41) a. | Jan was om t1 <i>nog altijd niet</i> aan het slapen.<br>'John was <i>still not</i> asleep at t1.' | 0 | 1 | 0 | 0 | 1 |
| b.      | Jan viel om t2 in slaap.<br>'John fell asleep at t2.'   |   |   |   |   |   |
| c.      | Jan was om t3 <i>eindelijk</i> aan het slapen.<br>'John was <i>finally</i> asleep at t3.'         | 1 | 1 | 1 | 0 | 0 |

As was observed with the dynamic continuity inferences in (19) and (22) the polarity transition at t2 in (41b) corresponds to switching the C-value from 0 (prospectivity) to 1 (retrospectivity). The reversal of the dynamic C-parameter then correlates with that of the more static A-parameter for the actual polarity. The co-occurrence restriction in (32) furthermore requires that either the D- or the E-parameter is reversed (but not both). Since the D-parameter does not concern the notion of polarity, whereas the E-parameter does, it is obviously the latter that is reversed along with the A- and C-values. The validity conditions are summarized in (42):

- (42) A dynamic focus inference is valid if and only if
1. the C-value is switched from 0 to 1: C = perspective
  2. the A- and E-values are reversed: A = actual polarity  
E = (counter)factualty of expectation
  3. the B- and D-values are preserved: B = polarity transition  
D = expectation/evaluation

In other words, valid temporal reasoning can only concern one single polarity transition consisting of adjacent and opposite polarity areas (B remains constant) and has to preserve the original subjective dimension of expectation (D remains constant). Consider the inference pattern in (43) which differs from the one in (41) in two respects: it relates to the polarity transition of finishing instead of that of beginning (B=0) and it has positive instead of negative focus (D=1):

- |         |   | A | B | C | D | E |
|---------|---|---|---|---|---|---|
| (43) a. | Jan was om t1 <i>al bijna niet meer</i> aan het slapen.<br>'John was <i>already almost no longer</i> asleep at t1.' | 1 | 0 | 0 | 1 | 0 |
| b.      | Jan werd om t2 wakker.<br>'John woke up at t2.'   |   |   |   |   |   |
| c.      | Jan was om t3 <i>al niet meer</i> aan het slapen.<br>'John was <i>already no longer</i> asleep at t3.'              | 0 | 0 | 1 | 1 | 1 |

According to the co-occurrence constraint in (32) the reversal of the C-value needs to be combined with that of either A or B (but not both) as well as with the reversal of either D or E (but again not both). This means that the valid configuration of (42) which reverses the ACE-values is only one out of four logical possibilities, the other three being ACD, BCE and BCD. The first two of these only deviate from the valid ACE configuration in one dimension, whereas the latter deviates in two dimensions. The inferences in (44) illustrate the ACD and BCE patterns:

- |         |   | A | B | C | D | E       |
|---------|---|---|---|---|---|---------|
| (44) a. | Jan was om t1 <i>nog altijd niet</i> aan het slapen.<br>'John was <i>still not</i> asleep at t1.'               | 0 | 1 | 0 | 0 | 1       |
| b.      | Jan viel om t2 in slaap.<br>'John fell asleep at t2.'   |   |   |   |   |         |
| c.      | ?? Jan was om t3 <i>al</i> aan het slapen.<br>?? 'John was <i>already</i> asleep at t3.'                        | 1 | 1 | 1 | 1 | 1 (ACD) |
| c'.     | *Jan was om t3 <i>eindelijk niet meer</i> aan het slapen.<br>*'John was <i>finally no longer</i> asleep at t3.' | 0 | 0 | 1 | 0 | 0 (BCE) |

With *al* in (44c) the A- and C-values are properly reversed but the D-value of focus is reversed instead of the E-value. As a consequence, the original negative evaluation associated with *nog altijd niet*, namely LATER THAN EXPECTED, is incorrectly turned into the positive evaluation associated with *al*. However, this deviance with respect to the E-parameter is definitely not as bad as that with respect to the A-parameter which occurs in (44c') with *eindelijk niet meer*. Although in this case the negative focus of the D-parameter is preserved, switching the B-value instead of the A-value causes the crossing of two polarity transitions in one step, i.e. from the negative polarity area before the beginning all the way into the negative polarity area beyond the finishing. The invalid inference pattern in (45), which deviates from the valid ACE configuration both in the A- and the E-dimensions, then combines the problems of (44c) and (44c'): the negative focus evaluation is not maintained and two polarity transitions are moved across simultaneously:

- |         |   | A | B | C | D | E |
|---------|---|---|---|---|---|---|
| (45) a. | Jan was om t1 <i>nog altijd niet</i> aan het slapen.<br>'John was <i>still not</i> asleep at t1.' | 0 | 1 | 0 | 0 | 1 |
| b.      | Jan viel om t2 in slaap.<br>'John fell asleep at t2.'   |   |   |   |   |   |

- c. \*Jan was om t3 *al niet meer* aan het slapen. 0 0 1 1 1 (BCD)  
 \*‘John was *already no longer* asleep at t3.’

As was the case with the continuity inferences in (22c’) the mechanisms of dynamic and static temporal reasoning can be integrated straightforwardly. In other words, the basic dynamic pattern of (41) can get a number of static extensions, as illustrated in (46):

		A	B	C	D	E	
(46) a.	Jan was om t1 <i>nog altijd niet</i> aan het slapen. ‘John was <i>still not</i> asleep at t1.’	0	1	0	0	1	
b.	Jan viel om t2 in slaap. ‘John fell asleep at t2.’						
c.	Jan was om t3 <i>eindelijk</i> aan het slapen. ‘John was <i>finally</i> asleep at t3.’	1	1	1	0	0	(ACE)
d.	Jan was om t3 <i>eindelijk niet meer</i> wakker. ‘John was <i>finally no longer</i> awake at t3.’	0	0	1	0	0	(AB + P)
d’.	Jan was om t3 ( <i>?al</i> ) aan het slapen. ‘John was ( <i>?already</i> ) asleep at t3.’	1	1	1			(keep ABC)
e.	Jan was om t3 <i>niet meer</i> wakker. ‘John was <i>no longer</i> awake at t3.’	0	0	1			(AB + P or keep ABC)

The above chain of valid temporal reasoning demonstrates that the conclusion of the dynamic reasoning in (46c) can function as the top node of a lattice structure, such as (40), which represents the valid static reasoning patterns. The focus construction in (46d) then represents the intermediate node on the left-hand track, where the dynamic reversal of the ACE-values is followed by the static reversal of the AB-values in combination with the substitution of the contradictory predicate. Hence, switching the adverbial BCE-values and negating the predicate yields a perfectly valid dynamic inference. The continuity construction in (46d’), on the other hand, corresponds to the intermediate node on the right-hand track: after the ACE-reversal one steps down from the five- to the three-dimensional level preserving the ABC-values. Finally, the continuity expression in (46e) can be seen as the bottom node of the lattice structure. It is either the result of reducing the focus form in (46d) to a continuity form, or else the result of reversing the AB-values and the predicate of the continuity form in (46d’).

#### 4. Conclusion

In this paper two groups of Dutch adverbial expressions were assigned a semantic representation, namely the adverbials of aspectual continuity, such as *nog (still)* and *nog niet (not yet)* and those of aspectual focus, such as *nog altijd niet (still not)* or *al niet meer (?already no longer)*. In both cases a bit-string formalism is proposed which generalizes the basic distinction between positive and negative polarity. The continuity adverbials receive a three-dimensional bit-string representation, whereas the focus adverbials require a five-dimensional bit-string representation in order to capture the idea of alternative expectations.

These bit-string representations are then first of all used to account for static temporal inferences, which concern one single information state. Two elementary valid patterns can be distinguished: (1) “preserve the A-value and ignore everything else” and (2) “ignore the last two parameters but preserve everything else”. With the continuity expressions these two have the same effect, i.e. the valid inference from ABC to A. With the focus expressions on the other hand, the former pattern yields valid inferences from ABCDE to A, whereas the latter yields valid inferences from ABCDE to ABC. In addition, the relationship of internal negation, which reverses the AB-values, is defined both for the continuity and the focus adverbials. This relationship gives rise to logical equivalences

when the AB-reversal on the adverbial is neutralized by the substitution of the contradictory verbal predicate. The unidirectional inferences and the equivalences can furthermore be combined in either order to yield a lattice structure of valid static temporal inferences.

The dynamic perspective on temporal reasoning then tries to account for the fact that when new information is added, certain components are updated, whereas other components remain constant across information states. More in particular, the minor premiss of the syllogistic argumentation pattern triggers a polarity transition which switches the C-value from 0 in the major premiss to 1 in the conclusion. As a consequence, the values of both the A- and the C-parameter in the major have to be reversed in the conclusion. In other words, valid reasoning depends on preserving the B-value of the polarity transition (beginning or ending) as well as the D-value of the subjective focus evaluation ('faster or slower than expected'). In a final step it is demonstrated how the static and the dynamic perspectives on temporal reasoning may interact to yield complex but valid inference patterns.

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