Limitations of a modal analysis of *before* and *after**

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Abstract This article takes a critical view of Beaver & Condoravdi's (2003) modal analysis of *before* and *after*. According to their proposal, the clause headed by *before* or *after* denotes the earliest possible time at which it is true. We first show that the original proposal presented by Beaver & Condoravdi (2003) faces difficulty with anti-veridical *before*-clause cases. We then incorporate eventualities (events and states) into a revamped proposal in which the existence of an eventuality that could lead to a *before*-clause eventuality and that parallels a very similar eventuality in the actual world is used as a criterion for selecting the set of alternative worlds. This allows the alternative worlds to differ from the actual one at a time earlier than the matrix clause predication time. However, this revision still suffers from counterexamples that involve *before* clauses that refer back to a time before the matrix clause eventuality. This discussion leaves room for the possibility that an extensional account might offer a better analysis.

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1 Introduction

The semantics of *before* and *after* when they head clausal complements is subject to much debate in the literature. There are two opposing positions regarding the semantics of *before* and *after*: an extensional analysis has been pursued first by Anscombe (1964) and continued by Landman (1992) and Krifka (2010), while a modal analysis has been proposed by Beaver & Condoravdi (2003) (abbreviated as B&C in the rest of this article). In this article, we shall present difficulties for B&C's modal analysis of *before* and *after*, leaving room for the possibility that an extensional alternative might provide a better analysis.

At first glance, *p before q* appears to be semantically equivalent to *q after p*. However, there is an intriguing complication. Some occurrences of *before* clauses are non-veridical (or non-factual) in that their complements are not necessarily true even when the entire sentence is true. Following Heinämäki (1974), we classify them into two subtypes of non-veridical *before* clauses. (1a) contains a <u>non-committal</u> *before* clause in that it may or may not have become true; (1b) contains a *before* clause that cannot be true when the entire sentence is true. Henceforth, we will refer to the latter type of *before* clauses as <u>anti-veridical</u>.[1]

(1)　　a.　I left the country before anything happened.
　　　　b.　Max died before he saw his grandchildren.[2]

(1b) means that Max died at a past time and could not see his grandchildren before his death (or after his death for that matter).[3] This interpretation is

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1 This corresponds to what B&C refer to as counterfactual *before* cases.

2 This is an example cited in Heinämäki 1974: p. 76.

3 Some native speakers express the intuition that (1b) is not fully grammatical and a tense form like *would* + V (e.g., *would see*) is strongly preferred. If this is the case, we can remove the extra semantic effect of the past tense and move the entire event to the future as in (i).

(i)　　Max might/will die before he sees his grandchildren.

This type of complication does not occur in a language like Japanese in which the 'before' clause does not occur in the past tense even when the matrix clause is in the past tense (Ogihara 2022). This factual claim about the past tense in English *before* clauses should be taken seriously. However, we will not discuss how to account for it in this article. In our discussion of B&C's proposal and its subsequent revision, we will rely on the Mozart example (6a) (*Mozart died before he finished the Requiem*), which appears to be immune to this issue perhaps because the verb *finish* induces the presupposition that Mozart started working on the Requiem. In Section 5, where we present empirical issues with the revised

contributed by our pragmatic assumptions about seeing: you have to be alive to be able to see. (2a), on the other hand, can only receive a pragmatically implausible reading and is anomalous: Max died and then saw his grandchildren.

(2)   a. #Max saw his grandchildren after he died.
      b.   Max died after he saw his grandchildren.

Unlike *before* clauses, *after* clauses are always veridical, and (2a) is no exception. Therefore, in order for (2a) to be true, Max has to be able to see people posthumously. The veridicality of *after* is also confirmed by (2b), the truth of which requires the truth of the *after* clause as well.

In this article, we shall present some difficulties for Beaver & Condoravdi (2003), who propose a modal analysis of *before* and *after* clauses and claim that 'A before B' means "A before the earliest possible time at which B is true."[4] This article is structured as follows. Section 2 discusses B&C's analysis of *before* and shows that it does not make clear how to account for the problem with anti-veridical *before* clauses. B&C acknowledge the need for backtracking, i.e., the need for positing some alternative world that diverges from the actual one before the matrix predication time. However, the details of how this can be done successfully without producing unwanted results are unclear. We then draw an analogy with the English progressive (Section 3) and use this to provide a re-interpretation of B&C's proposal in terms of eventualities (events and states; Section 4).[5] In Section 5, we show that even this version faces empirical problems with *before* clauses that refer to times before the matrix clause predication time. Additional issues with the revamped version of B&C's account are also discussed in this section. Section 6 concludes.

2   Beaver and Condoravdi's analysis and its problems

Beaver & Condoravdi (2003) propose an analysis of *before* and *after* in which their clausal complement has the same type of denotation: the earliest time

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version of B&C's proposal, we shall use examples in which the entire situation lies in the future of the utterance time. This enables us to avoid the said problem entirely.

4 Similarly, 'A after B' is claimed to mean "A after the earliest possible time at which B is true."

5 The term 'eventuality' is due to Bach (1986), who proposes this term so that it applies to both events and states. We will use this term in the description of the revamped B&C proposal so that it covers both events and states.

at which the clause is true in any of the "alternative worlds." This section will present some empirical problems with B&C's proposal. Let us first present the essence of B&C's proposal of *before* and *after* in (3) (Beaver & Condoravdi 2003: p. 50). In (3a), X represents a proposition that maps any world-time pair to a truth value.

(3)   a.   For a set W of worlds,
             $\text{earliest}_W(X) := \text{earliest}(\lambda t. \exists w \in W. X(w,t) = 1)$
             (= the earliest time in $\{t : \exists w \in W \text{ s.t. } X \text{ is true at } \langle w, t \rangle\}$)
       b.   'A before B' is true in w iff $\exists t$ s.t. $A(w,t) = 1$ and
             $t < \text{earliest}_{\text{alt}(w,t)}(B)$
             'A after B' is true in w iff $\exists t$ s.t. $A(w,t) = 1$ and
             $t > \text{earliest}_{\text{alt}(w,t)}(B)$

In the rest of this article, let us refer to the time at which the matrix clause is/was true as the **A-time** for convenience.[6] Analogously, we refer to the (earliest) time at which the *before* (or *after*) clause is true (or could be true) as the **B-time**, when doing so does not obscure our intention. The notation $\text{earliest}_W(X)$ given in (3a) refers to the earliest time at which X is true in any world in W. Here, X is a set of world-time pairs.[7] Given this, "$\text{earliest}_{\text{alt}(w,t)}(B)$" in (3b) means 'the earliest time at which B is true in any world in $\text{alt}(w,t)$'. Here, $\text{alt}(w,t)$ is a set of *alternative* worlds selected in terms of world w and time t.[8]

 The worlds in this set are among those that are identical to w up to (or until shortly before) t and could diverge from it thereafter. The technical details of this implementation will be discussed below. The intuition represented in (3b) is that the earliest possible time for the clausal complement of *before* to be true (among the probable alternatives to the actual world) is later than the A-time, and the earliest possible time for the clausal comple-

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6 This does not mean that the matrix clause past tense receives a referential interpretation. Rather, the A-time is a time that satisfies the existential claim made by the matrix clause and is used as the time of evaluation for the interpretation of the temporal adverbial clause. Similarly, we sometimes use variables in our informal exposition as if they are constants even when the corresponding variables are existentially bound in the formal version. This is for ease of exposition.

7 We assume the following semantic types: e for individuals/entities, t for truth values, i for time intervals, ϵ for eventualities (needed in Section 4), and s for worlds.

8 Beaver & Condoravdi deal with veridical *before* cases by assuming that the set of alternative worlds is the singleton that contains the actual world.

ment of *after* is earlier than the A-time.[9] We will discuss a difficult issue with B&C's proposal in what follows.

Let us examine the details of the semantics of *before* clauses in B&C's proposal and the empirical predictions it makes.[10] It is crucial to characterize precisely the function alt so that we know what set of worlds is in $\text{alt}(w, t)$. Following Thomason (1984), B&C specify alt in terms of an equivalence relation[11] $\simeq_t$ defined for any time t on the set of worlds W satisfying the conditions in (4a) and (4b). B&C stipulate that the equivalence relation must also satisfy the condition (4c). That is, if worlds w and w' are in the same equivalence class at time t, then they are also in the same class at any preceding time.

(4)   a.   Initial branch point condition: $\text{alt}(w, t) \subseteq \{w' : w \simeq_t w'\}$
        b.   Normality condition: $\text{alt}(w, t)$ contains only those historical alternatives of w at t that are reasonably probable given the course of events up to t
        c.   If $w \simeq_t w'$ and $t' < t$, then $w \simeq_{t'} w'$

(4a) and (4b) show that there are two steps to the characterization of $\text{alt}(w, t)$. First, we need to define $\simeq_t$ precisely. We then obtain $\text{alt}(w, t)$ as a subset of the set of worlds $\{w' : w \simeq_t w'\}$ in terms of the Normality condition (4b). Note that we need to be able to account for anti-veridical *before* cases like (5), which repeats (1b).

(5)   Max died before he saw his grandchildren.

In order to make (5) true, in some non-actual world, Max must continue to live and see his grandchildren at a time later than the A-time. That is, assuming that Max actually dies in w_0 at t_0, there is at least one world in $\text{alt}(w_0, t_0)$ in which Max lives long enough to see his grandchildren. This means that w_1 is

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9 Unlike the case of *before*, *after* clauses are always veridical because the alternative worlds in question are "the same" before the A-time. Therefore, the earliest possible *after*-clause situation is required to be realized in the actual world. In other words, *after* clauses are always veridical in B&C's account.

10 Rett 2020 is an important recent contribution to the topic at hand. Unlike the present article, Rett's main focus is adjusting B&C's analysis to better account for divergent cross-linguistic aspectual facts. Since anti-veridical *before* is not her main concern, her proposal shares many key properties with B&C's proposal. Thus, our contribution is independent of hers.

11 An equivalence relation on a set X is a binary relation that is reflexive, symmetric, and transitive.

not identical with w_0 at t_0. Since alt(w, t) is a subset of $\{w' : w \simeq_t w'\}$, we must allow the equivalence relation $\simeq_t$ to include some pairs of worlds that are distinct at t and possibly even before that.

Consider the case of (6a), which is also an anti-veridical *before* case and makes the same point as (5). In B&C's proposal, the *before* clause in (6a) is taken to indicate that the earliest possible time (among the relevant alternative worlds) of Mozart's finishing the requiem is later than the actual time of his death. B&C claim that this intuition is partially supported by a counterfactual conditional like (6b), which is arguably true in the given situation.

(6)   a.   Mozart died before he finished the Requiem.
      b.   If Mozart had not died when he in fact did (If Mozart had lived longer), he might/would have finished the requiem.

At first sight, this claim appears to be reasonable. The intuition is that we posit a set of possible worlds in which Mozart did not die even though he did in the actual world, and in some of them, he would have completed the Requiem that he was composing. However, when we look at the formal details given in (4), it is not clear how this proposal could be implemented.

Beaver & Condoravdi (2003: p. 50) are aware of the issues having to do with examples like (6a) and acknowledge that alt(w, t) consists of the worlds that are maximally similar to w but are not necessarily identical to w at t. If all the alternative worlds were identical to the actual world at t, then Mozart would have died at t in all of these worlds and he cannot possibly complete the Requiem in any of them at a time later than t. What this has to mean is that the relevant worlds are exactly like the actual one until shortly before t (which is the A-time in question) and branch away from it thereafter.

How should we then define the equivalence relation for cases like (5) and (6a)? It definitely does not suffice to define it in such a way that a world w' is in the same class as w at t iff they are identical at all times preceding t but not at t. Formally, the equivalence relation on this scenario is defined as in (7). We assume that the times in question are moments.

(7) $w_1 \simeq_t w_2$ iff w_1 and w_2 are identical at all times $t_1 < t$

Technically, (7) allows the two worlds in question to be completely identical until a fraction of a second before t but distinct at t. However, this intuitively makes no practical difference in the two worlds at t. If Mozart died at t in the actual world, he was definitely destined to die a fraction of a second before

that. Therefore, in order for Mozart to live longer, we would need more substantial backtracking. In other words, we have to allow members of $\text{alt}(w, t)$ to be distinct from w for a substantially longer interval that abuts t. For example, we may have to allow Mozart in one of the alternative worlds to be sick but not dying six months before t. This may allow him to be well enough in that possible world to live beyond t to complete the Requiem. If we adopt this strategy, however, we are not sure how to define the equivalence relation; it is not clear what kind of differences between worlds are tolerated for them to count as "similar enough" or how far back in relation to the A-time the worlds in question could differ from w. Specifying a fuzzy backtracking time frame as in (8) seems to be *ad hoc* and has limited predictive power.

(8) $w_1 \simeq_t w_2$ iff there is a time $t_1 < t$ such that t_1 is not "too far back" and w_1 and w_2 are identical at all times until t_1

In addition, backtracking might allow for completion of the Requiem in some alternative worlds before the actual time of Mozart's death unless we have some way of constraining the backtracking mechanism. This would be a very undesirable consequence.

3   Comparison with the English progressive

The discussion of the similarity (or identity) between the actual world and the alternative possible worlds that are considered to be "close enough" to the actual one resembles an issue for Dowty (1979)'s semantics of the English progressive and its criticisms.[12] Dowty (1979) proposes a modal-temporal analysis of the English progressive as in (9a) which employs the function *Inr*, which applies to an interval-world pair and yields a set of worlds called "inertia worlds." Dowty (1979: p. 148) characterizes inertia worlds as in (9b).[13]

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[12] Condoravdi (2009) mentions this in her presentation. We thank a S&P reviewer for pointing this out to us.

[13] (9a) assumes an interval-based semantic system (Bennett & Partee 2004, Dowty 1979) in which the denotation of each expression is determined directly with respect to an interval rather than a moment. This system will be discussed in detail in Section 4.

(9)   a.   PROG(φ) is true at $\langle I, w \rangle$ iff there is an interval $I' \supset I$ s.t. I is not
            a final subinterval for I' and for all $w' \in \text{Inr}(\langle I, w \rangle)$, φ is true at
            $\langle I', w' \rangle$.
      b.   Inertia worlds — $\text{Inr}(\langle I, w \rangle)$ — are to be thought of as worlds which
            are exactly like the given world up to the time in question and in
            which the future course of events after this time develops in ways
            most compatible with the past course of events.

Dowty's proposal was meant to provide a solution to the "imperfective
paradox," which concerns progressive accomplishments and achievements.
According to Bennett & Partee's seminal analysis of the English progressive,
(10a) entails (10b), which is intuitively incorrect. In other words, our intu-
itions say that the existence of an ongoing process of Mary's building a house
does not guarantee the existence of a complete house built by Mary at a later
time.

(10) a.   Mary is building a house.
      b.   Mary will have built a house.

Dowty refers to this problem as the imperfective paradox. His solution given
in (9) is that the completion occurs in the inertia worlds defined with respect
to the evaluation world/time. Intuitively, we should think of worlds in which
Mary continues to build a house in the future, and the house she is building
now will be completed in these worlds. However, this proposal was criticized
by Vlach (1981) and Abusch (1985) among many others because of examples
like (11).

(11) Robin was crossing the street when she was hit by the bus.

The problem with (11) for Dowty's original proposal is that although it cap-
tures the essential intuition that a relevant event of Robin's crossing the
street was ongoing at the relevant past time, the natural consequence of
what is described by the sentence is that she was hit by the bus and she
never reached the other side. In fact, in order to make sure that Robin gets
to the other side in any alternative worlds, we have to enable backtracking.
For example, if Robin started to move toward the other side of the street at
the same time as in the actual world, she would have to slow down or stop
momentarily to avoid the bus, etc. This type of backtracking, even if this is
sufficient to let Robin cross the street successfully, already casts doubt upon
the idea that the selection of the worlds is based on the course of events up

until the time of the matrix clause situation since that is the time of the event of Robin's being hit by the bus. This suggests that thinking about the overall natural course of events in the world at the A-time does not work. This problem is similar to that which B&C face regarding their proposal about *before* and *after* based on an equivalence relation on the set of worlds.

In order to resolve the issue, we need to pay attention to some specific ongoing event and exclude other events and properties of the world that prevent the ongoing event to continue. This is what Landman (1992) does in his proposal. Landman proposes an intensional analysis based on event continuation. Landman's analysis is presented in (12a, b). The semantics of PROG is given in (12c).

(12) a. Mary was building a house.
      b. $\exists e'[t(e') < \text{now} \land \text{PROG}(e', \lambda e.\exists y(\text{House}(y) \land \text{Build}(e) \land A(e) = m \land T(e) = y))]$[14]
      c. $[\![\text{PROG}(e, P)]\!]^{w,g} = 1$ iff $\exists f \exists v : \langle f, v \rangle \in \text{CON}(g(e), w)$ and $[\![P]\!]^{v,g}(f) = 1$,
          where $\text{CON}(g(e), w)$ is the continuation branch of $g(e)$ in w.[15]

(12a) is translated as in (12b), which means that there was a past event e that could become a complete event of Mary's building a house under reasonable assumptions. The crucial part of Landman's analysis is in the semantics of CON. CON stands for 'continuation branch' and is a function that maps an event-world pair $\langle e, w \rangle$ to a set of event-world pairs $\langle e', w' \rangle$ such that e' in w' counts as a "reasonable extension" of e in w. The intuitive content of this proposal can be explained in the following way. We check to see if the event e in the actual world is interrupted by some external force in the actual world. If that happens, we then move to a possible world in which this interruption does not occur and the event in question continues. We keep doing that until a complete event is obtained in some possible world that counts as a possible extension. If no reasonable extension is possible, the original progressive sentence is false. We will see if Landman's analysis for

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14 (12b) and (12c) are taken directly from Landman (1992). The system he assumes is similar to that of PTQ (Montague 1973) in that the formula in (12b) is an expression in the translation language that needs to be interpreted. In the formula, t denotes the function that maps an event to its temporal trace; A stands for agent, and T for theme.

15 In (12c), f and v stand for an event and a world, and g is an assignment function. CON is a two-place function that applies to an event-world pair and yields a set of event-world pairs.

the English progressive can be extended to the semantics of anti-veridical *before*.[16]

Applying Landman's analysis of the progressive to the case of *before* clauses is conceivable because the discussion of their semantic properties involves similar issues and ideas having to do with a selected set of possible worlds. In general, *before* clauses are anti-veridical when the matrix clause event prevents the *before* clause from becoming true. This is also similar to the imperfective progressive in that there could be some event that prevents the progressive event from being a complete one described by the sentence radical (without the progressive operator). However, there is an important difference between these two constructions that we need to attend to. Consider examples like those in (13).

(13) a. Mozart died before he finished the Requiem.
       b. Mozart was finishing the Requiem when he died.
       c. Mozart was composing the Requiem when he died.

(13a) and (13b) are not equivalent. (13a) says that Mozart died without finishing the Requiem, whereas (13b) says that Mozart was in the finishing stage of composing the Requiem when he died. Rather, (13a) resembles (13c) in meaning. In other words, (13a) only requires that he started the Requiem and was working on it when he died. The difference, then, is described in general terms as follows: An anti-veridical *before* clause indicates an event that entirely belongs to the future in relation to the A-time. By contrast, an imperfective progressive sentence describes an event that overlaps the time indicated by the *when* clause with the exception of futurate progressives (see the discussion of (15) below).

What is required by an anti-veridical *before* clause is the presence of an unexpressed eventuality (event or state), which could even be as vague as an expectation or plan, that might lead to a *before*-clause situation. Indeed, this is important for the felicity of anti-veridical *before* clauses as the oddity of (14) suggests.

(14) ? Beethoven died before he composed his 11th symphony.

It is true that Beethoven did not compose his 11th symphony. However, there is no evidence that it was being planned since he did not even compose his 10th symphony. Therefore, some type of planning or expectation must be present at the A-time in order for an anti-veridical *before* clause to occur felicitously. Given this argumentation, we believe that to revamp B&C's proposal, we need to posit an eventuality at the A-time (and before that) that causes an eventuality described by the *before* clause to occur.

Let us elaborate a bit on how we extend Landman's analysis (and similar considerations we learned from the past study of the progressive) to anti-veridical *before* cases. With a regular progressive sentence with an accomplishment predicate like (13b), one can identify a part of the eventuality described by the sentence (i.e., the process of working on the Requiem) and extend it in the set of relevant alternative worlds to see if this eventuality continues until it culminates. However, in the case of *before* clauses, the event described by the *before* clause generally has not started by the A-time. Thus, we must find a different eventuality at the A-time that could lead to a *before*-clause eventuality at a later time in some alternative world. In this sense, the case of anti-veridical *before* clauses is similar to that of futurate progressives such as (15). Note that at the utterance time, no buying eventuality is ongoing.

(15)   Mary is buying a house next year.

Dowty (1979: p. 158) discusses futurate progressives and concludes that in the case of (15), Mary's buying a house next year is planned or predetermined by the facts or events true at the utterance time. Landman (1992: p. 24) formalizes a similar idea by positing a planning stage of a complete event.

Given this model within Landman's account, we could modify B&C's proposal in such a way that the equivalence relation on the set of worlds W is eventuality-relative. That is, for a pair of worlds $\langle w_1, w_2 \rangle$ to be in the equivalence relation $\simeq_t$, they are either identical or contain eventualities that are considered to be counterparts of each other. Recall that what is happening at the A-time (or slightly before) is typically not part of an event that the *before* clause describes; the former is an eventuality that leads to the latter. For instance, in the Mozart example (6a), working on the Requiem should lead to the completion of the Requiem in some alternative world.

This, we believe, is a very reasonable approximation of what we need to account for the semantics of non-veridical *before* clauses within B&C's framework. For instance, in the examples in (16), it is arguable that there is

some event at the A-time that could lead to an event described by the *before* clause.

(16)   a.   Mozart died before he finished the Requiem.
          b.   The police defused the bomb before it exploded.

(16a) presupposes that Mozart was working on the Requiem, but he was not (necessarily) finishing it. Regarding (16b), there were presumably some indications that the bomb's explosion was imminent. The two-step approach under consideration seems to make the correct empirical prediction. In Section 4, we turn this approach into a complete proposal for a revised version of B&C's original.

4   Implementation of B&C's proposal in terms of eventualities

In this section, we will propose a concrete rendition of B&C's proposal that is empirically motivated. What we discussed in Section 3 gives us a clue as to how to do so. We also must make sure, per B&C's requirement, that if the worlds in question belong to the proposed equivalence class at t, then they also belong to the same equivalence class at any time earlier than t.

As mentioned in Section 3, the semantics of *before* clauses is similar to futurate progressives in English. We could therefore extend Landman (1992)'s analysis of the progressive to the futurate progressive and use the same technique to analyze *before* clauses. Specifically, Landman's analysis of the progressive considered in Section 3 can be extended to futurate progressives in that the event that is/was ongoing at the A-time leads to another event which is described by the sentence skeleton. Applying this idea to anti-veridical *before* cases like those in (16), we say that there was an eventuality at the A-time that could lead to a *before*-clause event at a later time.

Regarding (16a), there was a process of Mozart's composing the Requiem at the A-time. As for (16b), there was a state of the bomb's being about to explode at the A-time. They are not described by the *before* clauses, but they could lead to events that are described by them.

It seems reasonable to defend B&C's idea by assuming that there is/was an event or state that could lead to a complete event described by the *before* clause, and the earliest time of the *before* clause event (within a set of reasonable alternative worlds) is later than the A-time. Using the Mozart example, let us explain how the proposal works. The intuition is that in the relevant worlds, Mozart is composing the Requiem, though there may be differences

in how much of it he has completed and/or how his health is helping or impeding this process. Other events or states that might help or mitigate the process of composing the Requiem also differ across different worlds. Regarding the equivalence relation, we could say that the relevant possible worlds are either identical or differ slightly but that they all have an event of Mozart's working on the Requiem.

To be a bit more formal, we re-define the equivalence relation as in (17), which is now sensitive to both times and eventualities. We posit a model in which W is a set of possible worlds, T is a linearly ordered dense set of moments as is customary since Bennett & Partee 2004, and E is a set of eventualities. Bennett & Partee define an interval as a "gapless" subset of T and specify the denotation of each expression with respect to an interval directly, rather than a moment.[17]

From now on, the term *time* applies to intervals, which include moments as singletons. To avoid any confusion, we shall use the capital letter I to indicate intervals. Note also that START_w maps an eventuality in w to its starting moment. We also posit START (with no subscripted world), which maps a closed interval to its starting moment.

(17)   For any interval of time I, eventuality e_1, and worlds $w_1, w_2 \in W$ such that e_1 is in w_1, $w_1 \simeq_{I,e_1} w_2$ iff:

    (i)   there is an eventuality e_2 in w_2 which is understood as e_1's counterpart.[18]

    (ii) e_1 and e_2 occur throughout the interval $[\text{START}_{w_1}(e_1), \text{START}(I))$ $(= [\text{START}_{w_2}(e_2), \text{START}(I)))$ in w_1 and w_2, respectively.[19]

    (iii)   At all intervals $I_1 < \text{START}_{w_1}(e_1)$, w_1 and w_2 are identical.[20,21,22]

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17 According to Bennett & Partee (2004), $I \subset T$ is an interval iff for every $t_1, t_3 \in I$ and every $t_2 \in T$ such that $t_1 \leq t_2 \leq t_3$, $t_2 \in I$.

18 Counterpart eventualities are highly similar in that they share some essential properties such as the starting time and thematic participants.

19 To ensure that $\simeq_{I,e}$ is indeed an equivalence relation, we require that relevant event counterparts share the same agent and other participants (if any), in addition to the requirement that they share the same starting time.

20 To avoid the issue of identifying two (or more) eventualities in different worlds that are non-identical as the "same event," we consider these eventualities as formally distinct entities that share the same set of basic properties.

21 $[t_1, t) := \{t_2 : t_1 \leq t_2 < t\}$. This is based on the standard notation for intervals. Parentheses indicate open intervals; square brackets indicate closed ones.

The definition of the equivalence relation in (17) allows an alternative world w_2 to become distinct from w_1 before I as long as they contain events that start simultaneously, share the same set of participants, and run up until I (not necessarily including I). Note that the equivalence relation re-defined as in (17) introduces a new indeterminacy in that we need to be able to identify two distinct events in two different possible worlds as counterparts in order to render the two worlds as being related via the equivalence relation $\simeq_{I,e_1}$. It is clear that this procedure necessitates pragmatic considerations, which we will discuss later.

Based on this revamped proposal for the equivalence relation, we can now say that the set of relevant alternative worlds is eventuality-relative and is a subset of the equivalence class of worlds defined in (17), as symbolized in (18a). Following B&C, we will also adopt (18b) and (18c). (18b) is in the spirit of Landman (1992) in that the relevant counterpart eventuality continues to develop with fewer obstacles.

(18)   a.   For any world w, interval I, and eventuality e,
             $\text{alt}(w, I, e) \subseteq \{w' : w \simeq_{I,e} w'\}$

       b.   Event continuation condition: $\text{alt}(w, I, e)$ contains only those worlds w' in which the counterpart eventuality of e develops beyond I as long as this is reasonable.

       c.   If $w \simeq_{I,e} w'$ and $I' < I$, then $w \simeq_{I',e} w'$.

We are now ready to provide the truth conditions for 'A before B' under this new eventuality-relative system. As in the original B&C proposal, we ignore tense. Each sentence denotes a set of triples involving a world, an interval, and an eventuality. For example, the sentence radical *Mozart die* denotes $\{\langle w, I, e \rangle : e$ is an event of Mozart's dying in w at $I\}$.

Let us discuss the Mozart example (6a)/(16a) informally to provide the basic idea behind our revamped proposal. In order to make sure that in some alternative world, Mozart finished the Requiem, we identify an event in the actual world which is ongoing until the A-time, and is an event of his working on the Requiem. We can then define the set of alternative worlds in terms of the actual world, the time of his death, and the eventuality of his working on the requiem. The alternative worlds have an event of his working on the Requiem but they are allowed to differ from each other to some degree. The

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22 The relation of precedence between two intervals is defined derivatively as follows: for two intervals I_1 and I_2, $I_1 < I_2$ iff every member of I_1 precedes every member of I_2. See Bennett & Partee 2004.

claim made by the *before* clause then is that in at least one of the alternative worlds, Mozart lived on to finish the Requiem (after the actual time of his death). (19) shows how the system is formalized. Note that the term CAUSE in the definition is used for a relatively loose notion of causation in order to relate the eventuality ongoing before the A-time and the eventuality indicated by the *before* clause in question.

(19)   For any world w_0, interval I_0, and eventuality e_0,
    (i) $[\![A \text{ before } B]\!]^{w_0, I_0, e_0} = 1$ if $\langle w_0, I_0, e_0 \rangle \in [\![A]\!]$ and $\langle w_0, I_2, e_4 \rangle \in [\![B]\!]$ for some $I_2 > I_0$ and some eventuality e_4 in w_0;
    (ii) $[\![A \text{ before } B]\!]^{w_0, I_0, e_0} = 0$ if $\langle w_0, I_0, e_0 \rangle \in [\![A]\!]$ and $\langle w_0, I_2, e_5 \rangle \in [\![B]\!]$ for some $I_2 \leq I_0$ and some eventuality e_5 in w_0;
    (iii) Otherwise, $[\![A \text{ before } B]\!]^{w_0, I_0, e_0} = 1$ iff $\langle w_0, I_0, e_0 \rangle \in [\![A]\!]$ and I_0 precedes the earliest time I_1 such that there is an eventuality e_1 in w_0 that holds throughout an interval that abuts I_0 and there is a world $w_1 \in \text{alt}(w_0, I_0, e_1)$ in which an eventuality e_2, the counterpart of e_1, exists and causes an eventuality e_3 such that $\langle w_1, I_1, e_3 \rangle \in [\![B]\!]$.[23]

Let us continue to use the Mozart example to explicate the intuitive import of the formalization in (19). In it, e_0 corresponds to Mozart's death, and I_0 is its event time. This time must be earlier than the earliest time of Mozart's finishing the requiem (corresponding to e_3), which is calculated in the following manner. The eventuality e_1 is Mozart's working on the Requiem in the actual world. Technically, $\text{alt}(w_0, I_0, e_1)$ gives us a highly selective set of alternative worlds in which Mozart starts composing the Requiem at the same time as in the world w_0. In some alternative world (corresponding to w_1), the continuation of an event of Mozart's working on the Requiem (e_2) yields a finished product (i.e., e_3 indicates that). We then find the earliest time at which Mozart finished the Requiem in any world in $\text{alt}(w_0, I_0, e_1)$. The claim is that this time of Mozart's finishing the Requiem is later than the actual time of his death. This, we believe, is exactly what we would need within B&C's system. Note, however, that since e_1 and e_2 are distinct eventualities residing in different worlds, the only relevance of e_1 is that its counterpart e_2 in w_1 causes an eventuality (indicated by e_3 in (19)) represented by the *before* clause. Thus, the truth conditions are very weak and need to be strengthened by some

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23 We assume that $\text{alt}(w, I, e)$ can only be calculated if e is located in w at I. So (19) does not explicitly state that e_1 is located in w_0 at I_0.

contextual and pragmatic factors. We provide a graphic representation of the rough truth conditions for 'A before B' in Figure 1.
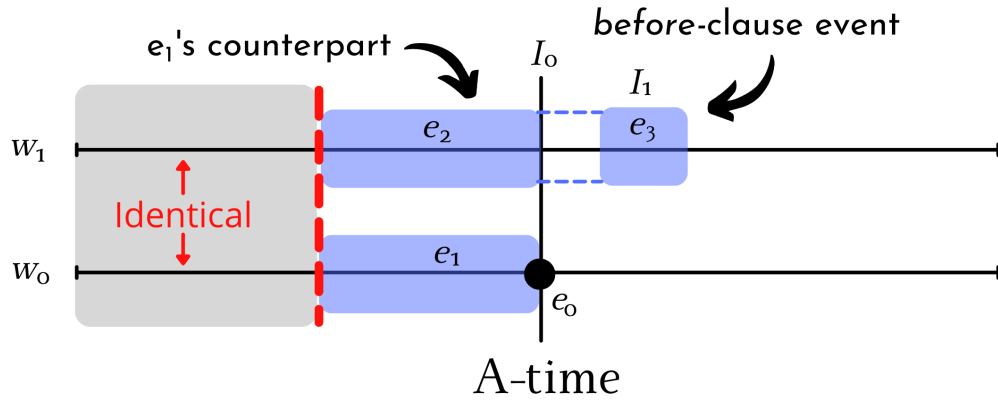
Figure 1   A visual rendition of the world, event, and interval structure described by the semantics for 'A before B' in (19).

The revamped B&C system successfully accounts for a variety of *before*-clause examples including anti-veridical cases.

5   Empirical problems with the eventuality-based B&C proposal

Section 4 developed an implementation of B&C's proposal in terms of eventualities. We shall claim in this section that the revised version of B&C's account still suffers from empirical issues. We shall consider cases involving anti-veridical *before* clauses that refer to times before the A-time, which are intuitively acceptable but induce contradictions in the revised B&C proposal. In addition, regarding non-committal *before* clauses, B&C's approach makes the selection of alternative worlds a rather tenuous process.

5.1   Examples that induce contradictions

We will discuss some felicitous anti-veridical *before* clauses that contain adverbials that refer to a time before the A-time. They induce contradictions within B&C's proposal unless they adopt a modal-temporal system completely different from Thomason's branching future model. Consider the examples in (20). The matrix clause is in the future tense in all of these sen-

tences. This enables us to avoid the veridical implicature of the past tense in a *before* clause, which some English native speakers claim exists.

(20)   a.   (Uttered in the middle of September 2021) Unfortunately, the 2021 MLB season will be over before Shohei Ohtani earns his 10th win of the season.
       b.   (Uttered on Christmas Day in 2020) 2020 might come to an end before it snows for the first time this year.
       c.   (Assume that Michel de Nostradamus predicted that in July 1999, a great King of terror would come from the sky and destroy the world.)
            (Uttered a few minutes before the end of July 1999) July 1999 will come to an end before Nostradamus' prophecy about the end of the world comes true.

Let us see how B&C's account, under our reinterpretation, fares with these examples.

(20a) has the PP *of the season*, which refers back to *the 2021 MLB season* used in the matrix clause. The A-time is the end of the 2021 season of Major League Baseball, which was October 3, 2021. The *before* clause says that Shohei Ohtani earns his 10th win of this season, which can only occur before the A-time. However, this is not possible in B&C's proposal since this time is required to be after the A-time.

The *before* clause in (20b) has the expression *this year*, which refers back to 2020. Since the first snow of 2020 can only occur in 2020, the modal proposal that posits a fictitious snow event after the end of 2020 does not work here.

Lastly, (20c) has a *before* clause that refers to Nostradamus' well-known prophecy about the end of the world. With the understanding that this prophecy specifically mentions the seventh month of 1999, it can only come true if the world is destroyed in July 1999. It cannot come true if this happens after the end of July 1999.

Recall that B&C's approach requires that each anti-veridical *before* clause be true at a time later than the A-time (in some relevant possible world). The examples in (20) show convincingly, in our opinion, that it does not work since it induces contradictory results.

To further strengthen our point, let us add a Japanese example that makes the same point. One advantage of drawing on Japanese is that its 'before' clauses are always in the "non-past" tense form and have no veridical impli-

cature (Ogihara 2022). Therefore, we can use an example in which the matrix clause is in the past tense as shown in (21), which parallels the English example given in (20a) except that the matrix clause is in the past tense.

(21) Zannen-na koto-ni, 2021-nen-no   siizun-wa   Ootani-ga
      Unfortunately,   2021-year-GEN season-TOP Ohtani-NOM
      zyussyoome-o ageru   mae   ni owat-ta.
      10th win-ACC earn.NON-PAST before at end-PAST
      'Unfortunately, the 2021 season ended before Ohtani earned his 10th
      win (of the season).'

(20b) and (20c) also have Japanese counterparts that make the same point.

Could B&C circumvent this temporal contradiction problem? Our conclusion is that this is not possible unless the crucial assumptions of the branching future model adopted by B&C are given up. In order to ensure that the earliest *before*-clause event occurs later than the A-time, we must extend the duration of the denotation of 2000 or shift its temporal location in such a way that a portion of this year is located after the A-time in some of the alternative worlds. This may be technically possible but goes against the assumptions we make about the nature of time and temporal terms we use. We believe that this type of example shows convincingly that coercing the "earliest time" of an anti-veridical *before* clause eventuality to be located later than the A-time in some alternative worlds is problematic.

5.2 Other issues for the revamped proposal

The eventuality-based revision we made to B&C's proposal regarding non-veridical cases has very weak truth conditions: a relevant counterpart eventuality in an alternative world must go on at least until the A-time and the continuation of this eventuality causes a *before* clause eventuality to occur. This does not seem to be sufficient for non-committal *before* clause cases since they typically involve situations that the subject entity wishes to avoid, and this type of information does not seem to be covered by the Event Continuation Condition (18b), which we adopted to select a set of alternative worlds.

Consider the putative non-committal *before* examples in (22).

(22) a. Mary will leave the party before Bill gets drunk.
      b. #Mary will leave the party before Quebec becomes an independent
          country.

Let us assume Mary and Bill will attend a party in Canberra, Australia. (22a) may be judged felicitous and true if Mary thinks that Bill might get drunk at the party, which she does not wish to see, and will leave the party early. Suppose that when Mary leaves the party, there are indications that Quebec in Canada might become an independent country at some time in the future. Even so, (22b) is not felicitous if it is uttered in the same situation as (22a). The relevant intuition is that Mary's leaving the party has nothing to do with the possibility of Quebec's becoming an independent country; Mary will leave the party early because she is worried about the possibility that Bill will get drunk. In order to make the right predictions, the proposal may need to guarantee that the alternative worlds are selected in terms of whether relevant eventualities are linked to the subject's reason for engaging in the eventuality described by the matrix clause. Thus, the Event Continuation Condition in (18b) might not be sufficient to make the correct empirical predictions here; additional contextual or pragmatic conditions might have to be imposed.[24]

6 Conclusion

In this article, we have shown that Beaver & Condoravdi (2003) face difficulty with anti-veridical *before* cases. We then modified B&C's original proposal slightly to incorporates eventualities by drawing an analogy with the English progressive. This proposal provides a possible account of anti-veridical *before* cases. However, this modification to B&C's system is still incapable of dealing with anti-veridical *before* clauses that refer to a time before the A-time. The proposal may also face difficulty with non-committal *before* cases. An extensional alternative to B&C's account of *before* and *after* could emerge from the above discussion, but the development of such a positive proposal must await future work.

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24 We thank a S&P reviewer for an additional possible issue involving presuppositions. (i) may be anomalous rather than false.

(i)   #Debussy died before he composed Fidelio.

The point of this example is that since Fidelio had already been composed by Beethoven, Debussy could not have composed it. In other words, this appears to be an instance of presupposition failure. The point is well taken, but this discussion would take us too far afield for the purpose of this article.

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