A Uniform Analysis of *Before* and *After*

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1. Introduction

Before and *after* have closely related meanings. How close? A *uniform* analysis would make their semantics differ only with respect to the direction of a temporal ordering relation.

Now one might think that *before* and *after* can not only be analyzed uniformly, but can be analyzed directly as temporal relations, with no more to be said about their meanings. In that case they would be logical converses, in the same way that the relations *earlier than* and *later than* are logical converses. In support of such a simple and intuitive account of *before* and *after*, (1) is true iff (2) is:

(1) Cleo left Europe before David did.

(2) David left Europe after Cleo did.

Surprisingly, a common view espoused by linguists and philosophers since Anscombe (1964) has been that *before* and *after* are not converses. According to an Anscombe-type analysis, (1) implicitly quantifies universally over times when David left Europe, whereas (2) involves only existential quantification. Such an analysis, involving differing quantificational force for the two operators, appears not only to imply non-converseness, but even to imply non-uniformity. However, the difference in quantificational force seems to have no independent motivation. Could there be a language with a counterpart of *before* that was purely existential, or one with a counterpart of *after* that was universal?

Three powerful empirical arguments seem to militate in favor of an account like Anscombe's, and against the view that *before* and *after* are converses:

1. Logical properties. For example, *before* but not *after* supports transitivity inferences;

2. Polarity item licensing. *Before* licenses negative polarity items, but *after* generally does not;

3. Veridicality. The complement of *after* is veridical, but that of *before* is not.

These arguments against converseness are presented below. But what does it mean to say that they are arguments against converseness? We can distinguish two notions of *converse*, one at the sentence level, and the other lexical. Let us say that *before* and *after* would be *sentence-level converses* if a sentence of the form *A before B* is truth-conditionally equivalent to *after A, B* (or *B after A*, if there are no anaphoric dependencies between *A* and *B*). On the other hand, we can call *before* and *after*

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lexical converses if each has a binary relation as its lexical meaning, and for any pair of argument meanings M, M', $[\![\text{before}]\!](M, M') \equiv [\![\text{after}]\!](M', M)$.

We claim that the three types of argument listed above show only that *before* and *after* are not sentence-level converses. The data does not bear on the question of whether *before* and *after* are lexical converses. The goal of this paper is to show that the evidence that *before* and *after* are not sentence-level converses, while completely convincing in its own right, is consistent with uniformity.

We first motivate and present the two best known analyses of *before* and *after*, the analyses of Anscombe and Heinämäki. These analyses are generally assumed to be competitors, but we will show that under certain plausible assumptions they are, in fact, truth-conditionally identical. We then demonstrate that both analyses, contrary to appearances, are uniform in the sense defined above, and we present a cleaner reformulation. Finally, we discuss how any such analysis should be extended to deal adequately with the third of the above arguments against uniformity, the argument from veridicality.

2. Asymmetries of *Before* and *After*

In this section we introduce the three arguments which appear to motivate non-uniform analyses of *before* and *after*: logical properties, NPI licensing and veridicality.

Anscombe based her case entirely on the first type of evidence, the differing logical properties of *before* and *after*. Specifically, Anscombe argued that while *before* is antisymmetric and transitive, *after* is neither, and she also provided direct inferential evidence that the two connectives are not (sentential) converses.

As regards antisymmetry, consider (3)–(6). (3) is true if and only if (4) is false, exemplifying the antisymmetry of *before*. However, (5) and (6) can be simultaneously true, as in the situation depicted in (7).

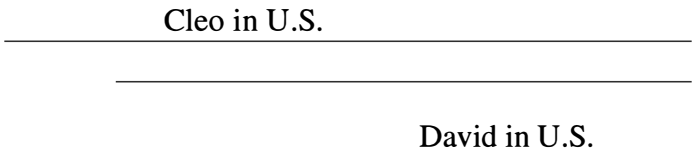
(3) Cleo was in America before David was in America.

(4) David was in America before Cleo was in America.

(5) Cleo was in America after David was in America.

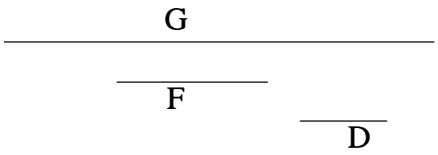
(6) David was in America after Cleo was in America.

(7)



Turning to transitivity, consider a movie in which Ginger dances continuously, and Fred dances in the middle; a few minutes after Fred has stopped dancing, and while Ginger continues to dance without stopping, Delores does a quick routine. The situation is depicted in (8).

(8)



For this situation, speakers asked about (9) or (10) judge them true, but judge (11) false, apparently showing that *after* is not a transitive relation. Note that when speakers are confronted with a complete argument like that in (9–11), they are sometimes defensive, as if the linguist is selling something they do not want to buy.

(9) Fred was dancing after Ginger was.

(10) Ginger was dancing after Delores was.

(11) Fred was dancing after Delores was.

We cannot construct similar examples to show that *before* is not transitive. Suppose we try to create an argument by reversing each clause in (9–11), replacing *after* by *before*, and then swapping the order of the two premises, yielding (12–14). The result is an intuitively valid argument, which is thus not a counterexample to the transitivity of *before*.

(12) Delores was dancing before Ginger was.

(13) Ginger was dancing before Fred was.

(14) Delores was dancing before Fred was.

The manipulations performed in order to create (12–14) do not preserve truth conditional content. Specifically, the premise (12) is not judged true in the situation in (8). This gives us a direct counterexample to sentential converseness of *before* and *after*. If the two connectives were sentential converses, one might expect any situation satisfying (10) also to satisfy (12), since this amounts to a pair of sentences with forms *X after Y* and *Y before X*, respectively. The fact that (8) satisfies (10) but not (12) thus provides a compelling reason to believe that *before* and *after* are not sentential converses.

The second phenomenon showing that *before* and *after* are not sentential converses is the licensing of negative polarity items (NPIs).[1] It is generally accepted (i) that NPIs are licensed in *before* clauses but not in *after* clauses, and (ii) that temporally modified main clauses do not license NPIs regardless of the temporal connective. These properties are illustrated by the following examples:

(15) Cleo leapt into action before David moved a muscle/could say a word.

(16) * Cleo leapt into action after David moved a muscle/could say a word.

(17) * David moved a muscle/could say a word before Cleo leapt into action.

(18) * David moved a muscle/could say a word after Cleo leapt into action.

Using Google to perform a web search for NPIs confirmed that *before* licenses NPIs. We found 30 instances of the NPI *moved a muscle*, 27 instances of the NPI *had the faintest idea*, and 10,200 instances of the NPI *could say a word* licensed by *before*. Examples follow:

(19) Bridge produced no reaction from Liverpool's back line, and Marsden chased after the ball and got himself a couple of yards clear before anyone moved a muscle.[2]

(20) I once spent 10 minutes staring at Trevor Lock before I had the faintest idea who he was.[3]

(21) [Sometime back in 1965 ...] Before Jones could say a word, Lennon looked at him and with a smirk began singing Tom's hit as he walked by. Problem was Lennon changed the words from, "It's Not Unusual" to, "It's Not A Unicorn, It's An Elephant" and kept walking.[4]

Google found no instances of *moved a muscle*, *had the faintest idea* or *could say a word* licensed by *after*. While we now believe that the licensing of NPIs by *after* is more complex than has been recognized previously, it is clear from this data that there is a considerable distributional asymmetry between *before* and *after*.

A web search did locate *moved a muscle*, *had the faintest idea* and *could say a word* in the main clauses of sentences with *before* and *after*. However, in a sample of such cases, all the NPI occurrences were found to be licensed independently of the temporal connective.

Ladusaw (1979) and others have argued that the main licensing condition for NPIs is semantic: they are licensed by operators producing a downward monotone context. If so, NPI distribution again shows that *before* and *after* are not sentential converses, since we would expect the same NPI distribution in an *after* main clause as a *before* sub-clause. Furthermore, if *before* marked temporal precedence, it is not immediately obvious why it would license NPIs at all.

The third issue apparently separating *before* and *after* concerns the veridicality of the temporal clause: *before* clauses can be non-veridical, while *after* clauses and main clauses are veridical.[5] The non-veridicality of *before* clauses is illustrated by the following examples:

(22) On Dec. 9, the U.S. Supreme Court stopped the hand count before it was completed.[6]
(Uncounted votes.)

(23) Another booby-trapped bicycle and a bomb hidden in a supermarket cart were discovered and defused by police before they exploded.[7]
(No explosion.)

(24) Mozart died before he finished the Requiem and it was completed by his student, Franz Xavier [Süssmayr].[8]
(Unfinished Requiem.)

If we replace *before* by *after*, no amount of toying with the examples leads to non-veridicality of either the main or the subordinate clause:

(25) Mozart died after he finished the Requiem.
(Requiem finished.)

(26) Mozart finished the Requiem after he died.
(Requiem finished post mortem.)

In sum, consideration of inferential properties, NPI licensing and veridicality provide a compelling case for analyzing *before* differently than *after*. We will now consider analyses which introduce such differences.

3. Anscombe

Anscombe proposed (essentially) the following definitions, in which A and B are sets of time points when A and B hold, respectively, and $<$ is temporal precedence:

(27)
$$\begin{array}{rll} \text{A before B} & \text{iff} & (\exists t \in A)\ (\forall t' \in B)\ t < t' \\ \text{A after B} & \text{iff} & (\exists t \in A, t' \in B)\ t > t' \end{array}$$

Crucially, while Anscombe's analysis of *before* involves universal quantification over times at which the temporal clause is true, her analysis of *after* is entirely existential. Clearly the definitions are non-uniform, and do not make *before* and *after* into sentential converses. For example, suppose A is true only during a finite subset of the time points when B is true. Then, under these definitions, *B after A* is true, but *A before B* is false. The other properties Anscombe observed follow as well:

Antisymmetry of *before* If *A before B* is true, then some *A* time precedes all *B* times, so clearly it cannot be the case that some *B* time precedes all *A* times.

Transitivity of *before* If some *A* time precedes all *B* times, and some *B* time precedes all *C* times, then clearly some *A* time precedes all *C* times.

Non-antisymmetry of *after* It is possible for some *A* time to precede some *B* time while some *B* time precedes some *A* time: this will be true whenever there is overlap between the *A* times and the *B* times.

Non-transitivity of *after* Consider the model depicted in (8). Here some *F* time is later than some *G* time, so *F after G* is true. Similarly, some *G* time is later than some *D* time, so *G after D* is true. Transitivity would suggest *F after D*, but on the definition of *after* this does not hold in the model, since there is no *F* time which is later than any *D* time.

Higginbotham (1988), Landman (1991) and Valencia et al. (1992) all adopt Anscombe's use of universal quantification in the interpretation of *before* to explain its ability to license NPIs. Even without considering how NPIs are licensed, one can see the argument by appeal to analogy: universal quantifiers like *every* license NPIs as in (28), and *before* licenses NPIs because it involves an implicit universal quantifier.

(28) Every woman who could say a word protested her innocence.

The argument is made more precise in terms of the standard account of NPI licensing due to Fauconnier (1975) and Ladusaw (1979). NPIs, it is claimed, are licensed in downward monotone environments. These are environments where set denoting expressions (e.g. *person*, understood extensionally as the set of people) can be replaced by expressions denoting subsets (e.g. *woman*, denoting a subset of *person*) while preserving truth. Thus if *every person smiled* is true, then *every woman smiled* is true, and it is on this basis that we predict licensing of NPIs by *every*.

Anscombe's semantics defines *before* clauses to be downward monotone, and it is on this basis that NPI licensing is predicted. Note that given the standard explanation of NPI licensing, *before* licenses NPIs just because it licenses certain inferences, though not inferences we have yet considered. The relevant patterns of inference, correctly predicted by Anscombe's analysis, have the following character:

(29) a. People are primates.

b. There were dinosaurs before there were primates.

c. So there were dinosaurs before there were people.

The set of times at which there were people is a subset of the set of times at which there were primates, so the valid inference from (b) to (c) is a subset inference of the type discussed with reference to *every*.

The lack of NPI licensing by *after* is also explained very easily in terms of Anscombe's analysis. She posits only existential quantification in the interpretation of *after*, but existentials do not support superset inferences. *Some person smiled* does not entail *some woman smiled*, and NPIs are not licensed by *some*:

(30) * Some woman who could say a word protested her innocence.

Similarly, Anscombe's analysis predicts subset inferences not to be valid for *after*, the following invalid argument being a case in point:

(31) a. People are primates.

b. There were dinosaurs after there were primates.

c. So there were dinosaurs after there were people.

We have now seen that Anscombe's analysis predicts both the original inference patterns that Anscombe herself discussed, and the NPI facts that were observed later. Anscombe's analysis has also been used to explain veridicality effects. Landman (1991) observes that Anscombe's universal quantification over the temporal clause does not entail existence. In other words, *A before B* says that there was an *A* time before all *B* times, but does not imply that there are any *B* times. Thus, *B* may never have happened. In contrast, Anscombe analyzes *after* clauses existentially, so it follows from *A after B* that *B* occurred.

Although the Anscombe/Landman analysis of veridicality effects is attractively simple, the truth conditions predicted are strange. For example, even if David never won a gold medal at anything in his whole life, provided he ate lots of ketchup at some point, (32) is predicted true.

(32) David ate lots of ketchup before he made a clean sweep of all the gold medals in the Sydney Olympics.

And (33) is predicted to be true even without the ketchup training regimen:

(33) Squares had four sides long before David made a clean sweep of all the gold medals in the Sydney Olympics.

Yet another problem with Anscombe's analysis arises when we consider measure phrases (e.g. *3 minutes before...*), although Anscombe herself did not discuss them. If extended in the most obvious way to deal with measure phrases, her analysis would make incorrect predictions for *before*. For example, in (34) Anscombe's proposal would lead us to expect that Cleo left exactly 5 seconds before every time point at which David was singing.

(34) Cleo left exactly 5 seconds before David sang.

Indeed, since it is impossible to leave continuously over a sustained period, then given that Cleo did leave at some point, (34) is predicted to be true iff David did not sing.

4. Heinämäki

Perhaps the best known alternative account is that of Heinämäki (1974), followed by related work such as Hinrichs (1986). Heinämäki's semantics is stated in terms of intervals rather than just time points. The connectives are analyzed as binary sentential operators, interpreted with the help of a reference point (*tr*), which can be used to anchor tense operators. The reference point depends on the aspectual class of the clause: (i) it is the final point of the interval at which the sentence in the clause is true for accomplishments; (ii) it is the initial point otherwise.

Heinämäki (1974:49,72) gives the following definitions (where I(B) is the initial point at which B is true, and we omit her references to tense information):

(35) A BEFORE B is true if and only if
(i) A is true at some interval,
(ii) B is true at some interval, and
(iii) tr(A) < I(B)

A AFTER B is true if and only if
(i) A is true at some interval J,
(ii) B is true at some interval, and
(iii) there is J' such that $J' \subseteq J$ and $J' > tr$(B)

The general definitions Heinämäki uses relating sentences to intervals at which they are true seem to allow that if a sentence holds at an interval, then it also holds at all subintervals of the interval. However, the intention of the definitions seems to be that a sentence is true only at maximal (continuous) intervals, such that it is not true at subintervals of those intervals. This assumption is also implicit in the definitions of *tr* and I.

Let us restate Heinämäki's definitions in a notation closer to that used for Anscombe's, writing A' for the set of intervals corresponding to sentence A (as opposed to A, a set of times corresponding to sentence A in the Anscombe definition). The definitions are then as follows:

(36) A before B iff $(\exists J \in A', K \in B')\ tr(\text{A}) < \text{I(B)}$
A after B iff $(\exists J \in A', K \in B', J' \subseteq J)\ J' > tr(\text{B})$

Define an interval to be a dense set of times, and assume that there is an interval corresponding to every such set. Let us further assume that the set of times corresponding to a sentential clause A is just the set of all times contained in intervals corresponding to A, i.e. $A = \{t \mid (\exists I \in A')\ t \in I\}$ and that all such intervals are left-bounded. Now if a time precedes an interval, it precedes all times in that interval. These assumptions allow us to rewrite Heinämäki's definitions without direct reference to intervals:

(37) A before B iff $(\exists t \in A, t' \in B)\ (\forall t'' \in B)\ tr(\text{A}) < t''$
A after B iff $(\exists t \in A, t' \in B)\ t > tr(\text{B})$

If B is non-empty, we will say that B is instantiated. Let us further note that the temporal reference point *tr* is only used for one of the clauses in the definitions. In case this clause picks out a state, activity or achievement, we can replace the temporal reference point by the first time at which the clause holds (although for activities this may be a non-trivial assumption). We can further use the fact that the first point in A precedes something *iff* some point in A precedes it. These observations allow us to rewrite the Heinämäki's definitions as follows:

(38) A before B iff $B \neq \emptyset \wedge (\exists t \in A)(\forall t' \in B)\ t < t'$
A after B iff $(\exists t \in A, t' \in B)\ t > t'$

We can now make the following assertion:

Proposition 1 In case all clauses are state, activity, or achievement denoting, and provided the temporal clause is instantiated and left-bounded, Heinämäki's truth conditions for *before* and *after* sentences are identical to those proposed by Anscombe.

In case we are dealing with accomplishments, it is only possible to provide an equivalence once we have decided at what times an accomplishment is true. Suppose we restrict our attention to simple accomplishments with point-like culminations (i.e. *ate the apple*, but not *ate at least three apples*). Then Heinämäki's definition of *tr* as the final point of an accomplishment amounts to taking *tr* to be the single point of culmination. It then follows that if we take the set of times corresponding to an accomplishment to contain only the point of culmination, we can extend Proposition 1 to include accomplishments in addition to the other aspectual classes.

Given the strong equivalence we have established between Anscombe's and Heinämäki's superficially quite distinct accounts, it also follows that, modulo the assumption of instantiation, Heinämäki's model can account both for the Anscombian inference data and for the NPI distribution data. Moreover, Heinämäki's semantics does not lead to the strange truth conditional effects in examples (32) and (33), since the temporal clause B is existentially quantified, thus ensuring that B is instantiated.

Another clear advantage of Heinämäki's analysis is that (although she does not present a full analysis) measure phrases should be unproblematic. The point is that *before* clauses are not universally quantified, but are analyzed in terms of a single initial point at which the clause begins to be true. The modifier *5 seconds* could then simply force *before* to pick out a point 5 seconds prior to this initial point.

Although Heinämäki improves on Anscombe by virtue of her explicit consideration of accomplishments, by not falling into the ketchup problems (32, 33), and by enabling a treatment of measure phrases, problems remain. She does not provide a uniform treatment of temporal modifiers: there are unmotivated differences between the meaning of *before* and *after* which we would like to see explained in terms of general principles. There also remain empirical shortcomings and open issues, especially as regards the treatment of accomplishments. But in this paper we will attempt to improve on Heinämäki empirically in only one respect, namely the treatment of veridicality.

5. A Uniform Analysis

The analyses of Anscombe and Heinämäki appear highly non-uniform. But this is deceptive. Using similar considerations to those which allowed us to show how these two prior analyses are related each other, we can show that both are equivalent to a uniform statement of the meaning of *before* and *after* sentences which differs only in terms of the direction of the temporal relation. Specifically, we use the following two trivial facts under the assumption that there is a first B time: (i) an A time precedes all B times *iff* it precedes the first B time, and (ii) an A time is later than some B time *iff* it is later than the first B time.

We assume that untensed sentential clauses, when instantiated, denote left-bounded sets of times, where a set T is left-bounded if there is $t \in T$ such that for all $t' \in T$, $t \leq t'$.[9] For left-bounded T, we call that t, *earliest*(T). Given the assumption of left-boundedness, *earliest* will always be defined for instantiated temporal clauses and will be undefined for uninstantiated temporal clauses.

Applying the equivalences above to Anscombe's definitions, assuming that B denotes a non-empty set, results in the following variant:

(39) A before B iff $(\exists t \in A)\ t < \textit{earliest}(B)$
A after B iff $(\exists t \in A)\ t > \textit{earliest}(B)$

Proposition 2 In case the temporal clauses are instantiated, the truth conditions in (39) are identical to those proposed by Anscombe. Under assumptions given in section 4 concerning the relationship between a clause's interval denotation and its time-point denotation, the truth conditions in (39) are identical to those proposed by Heinämäki.

Given proposition 2, and what we have already seen of the analyses of Anscombe and Heinämäki, it is clear the definitions in (39) do not make *before* and *after* into sentence-level converses. But could *before* and *after* be lexical converses? To answer this question, we would have to know which components of the semantics presented in (39) are present in the lexical entries for *before* and *after*, and which are introduced in the compositional build-up of the meaning. In fact, we show in Beaver and Condoravdi (2003) that the analysis is completely compatible with *before* and *after* being lexical converses.[10]

According to (39), there are three components to the semantics of *before* and *after*: an existential, a temporal ordering, and an operator *earliest*. What we describe in Beaver and Condoravdi (2003) is a fragment in which both the existential and the operator *earliest* arise in the compositional build up of sentential meanings, not in the lexical semantics of the temporal operators. The source of the existential is clear: in the semantics for both of the connectives, it is the main clause which is existentially quantified. We suggest that existential force is introduced by a tense operator, and that this is no different from sentences which lack a temporal modifier. In the fragment, the operator *earliest* is introduced as a way of coercing the set of times denoted by the clausal complement of the temporal connective into a single time point. This time point then becomes one argument of the temporal connective, the other argument being the existentially quantified time point introduced by the main clause.

It is interesting to observe that the choice of *earliest* as opposed to other operators that would coerce a set of times into a single time point has not been motivated independently. This is merely the choice that reproduces the results of Anscombe and Heinämäki. We speculate that some empirical anomalies remaining in these prior accounts can be resolved by using alternatives to *earliest*. Note, for example, that *Harrison was alive after Lennon was alive* seems to have an interpretation where it implies that Harrison outlived Lennon, and not merely that Harrison was alive at

some point after Lennon was born. Both Anscombe and Heinämäki make incorrect predictions about this example, and (39) inherits the same problems. It would make sense to consider an account in which the coercion operator applied to the temporal clause was selected pragmatically, but we will not pursue this line of research in the current paper.

It is also worth noting that the data considered in this paper is compatible with *before* and *after* being neither sentence-level converses nor lexical converses. For example, the operator *earliest* could be part of the lexical meaning of the connectives. Thus, *before* could have the lexical meaning $\lambda T \lambda t.t < \mathit{earliest}(T)$, and similarly for *after*. These meanings make both temporal connectives into relations between a set of times (T) and a single time (t), such that they are obviously not lexical converses.

6. Veridicality

A potentially more serious challenge for a uniform analysis of the connectives is their difference with respect to veridicality. As discussed in section 2, *after* is always veridical, in that *B* is entailed by *A after B*, while *before* is not. The analysis in (39) makes both connectives veridical since the instantiation of the temporal clause is required for the definedness of *earliest* and, hence, for the entire sentence to have a truth value. In this section we extend the analysis in order to account for this asymmetry and to properly characterize veridical and non-veridical readings of *before*. *Before* and *after* sentences still receive a uniform semantics, with the mechanism responsible for producing non-veridical readings for *before* simply producing only veridical readings for *after*.

It is necessary to characterize veridical and non-veridical readings of *before* whether one aims for a uniform analysis of the connectives or not. The asymmetry in veridicality between *before* and *after* is not simply a matter of universal vs. existential quantification over the temporal clause, as Landman (1991) or Valencia et al. (1992) claim, because *before* sentences are not just neutral as to whether the temporal clause is instantiated. For instance, (1) implies that David did in fact leave Europe, while the oddity of cases like (32, 33) has to do with the falsity of the temporal clause. On the other hand, cases like (22)–(24), where the temporal clauses are also false, are perfectly acceptable. The contrast between (1) and (32, 33) and that between (32, 33) and (22)–(24) need to be accounted for. Moreover, as shown already by Heinämäki (1972), non-veridical uses of *before* carry additional implications, which ought to be accounted for as well.

As discussed by Heinämäki (1972, 1974) and Ogihara (1995), on each particular occasion of use, *before* sentences get either a veridical or a non-veridical reading, and the non-veridical reading is either counterfactual or non-committal.[11] On the veridical reading of a *before* sentence, the temporal clause is implied to be true. On the counterfactual type of non-veridical reading, the temporal clause is implied to be false while a corresponding counterfactual conditional *If A had not been the case, B might/would have been the case* is implied to be true.[12] On the non-committal type

of the non-veridical reading, the temporal clause is implied to be/have been likely, with the eventual outcome unknown, either because the speaker never found out how things turned out to be or because the issue is not settled by the time of utterance.

Examples (22)–(24), presented in section 2 to illustrate the non-veridicality of *before*, all have a counterfactual reading. For instance, (24), repeated in (40) a bit simplified, implies (41).

(40) Mozart died before he finished the Requiem.

(41) If Mozart had not died when he in fact did, he might/would have finished the Requiem.

The counterfactual reading arises in contexts entailing that A's instantiation makes B's later instantiation impossible. The instantiation of A or the non-instantiation of B can, but need not, be presupposed. An example of the main clause being presupposed would be (40) uttered in a context in which it is taken for granted that Mozart died and that people do not do anything after their death but where it is not known whether Mozart actually finished the Requiem. The new information conveyed by (40) in such a context is that Mozart did not finish the Requiem and that he might/would have, had he not died when he actually did. An example of the negation of the temporal clause being presupposed would be (42) uttered in a context in which it is taken for granted that there was a bomb ticking which ended up not exploding.

(42) The police defused the bomb before it exploded.

The new information conveyed by (42) in such a context is that the reason the bomb did not explode, though it was about to, was that the police defused it before the time it would have exploded. An example of neither clause being presupposed would be (23) in the context of a news report where all that is taken for granted is that a defused bomb does not explode.

(43) is an example of the non-committal reading. Uttering (43) does not commit me to there having being trouble but it does imply that trouble seemed likely shortly before my departure.

(43) I left the party before there was (any) trouble.

The non-committal reading indicates uncertainty on the part of the speaker about the actual course of events and is to be distinguished from cases of hearer uncertainty about the reading intended by the speaker.[13]

An adequate analysis must show how these readings arise given the meaning of *A before B* and the context in which it is uttered. It must account for the readings of *before* without assuming lexical ambiguity, and in such a way so as to (a) make the veridical reading be about just how things actually are/were, not about how things might be expected to be/have been; (b) make the counterfactual reading be informative, communicating that a course of events in which B could have been realized is

interrupted once A is realized; (c) distinguish the non-committal reading from the disjunction of the other two.

Heinämäki (1972) and Ogihara (1995) propose refinements of the Anscombe-type analysis that accommodate veridical and non-veridical readings of *before*. Both proposals associate a presupposition with *before* and attribute its different readings to properties of the context in which it is used. Reducing the apparent ambiguity of *before* to its use in particular kinds of contexts is an important contribution of these works and it will be an aspect of our proposal too. On the other hand, in ascribing a presupposition to *before*, these proposals introduce an extra asymmetry between *before* and *after*,[14] without a fully satisfactory analysis of the different readings of *before*. Heinämäki's account of the veridical and counterfactual readings cannot be extended to the non-committal reading, and the counterfactual implication of the counterfactual reading is not tied to the truth-conditional or the presuppositional content of *before*. Ogihara's analysis in terms of a modal presupposition results in unwanted modal presuppositions for the veridical reading. (1), for instance, is predicted to be felicitous only relative to contexts entailing that David's leaving Europe was the expected thing to happen given the course of events up to a given time in the past.

Our analysis capitalizes on the need to satisfy the definedness condition of *earliest*, the operator implicated in the semantics of both connectives. If the temporal clause is instantiated in the world of evaluation, then the truth conditions of the connectives are, in effect, as specified in (39). If the temporal clause is not instantiated in the world of evaluation, *earliest* is relativized to an expanded domain of worlds, closely related to the world of evaluation. If *earliest* fails to be defined relative to this expanded domain, the sentence has no truth value. If it is defined, the truth conditional content of the sentence will reflect the expansion of the domain of worlds in which the temporal clause is instantiated, giving rise to modal implications. The counterfactual implications of the counterfactual reading thus arise as a result of the truth-conditional content of *before* sentences. Since *earliest* can be defined relative to alternative worlds to the world of evaluation, the connectives can be said to be modal. Given the way the alternatives are selected, from a particular forward branching structure of possible worlds, *after* is only trivially modal but *before* can be essentially modal.

Moving beyond the extensional setting we have been assuming so far, let us take untensed sentential clauses to denote sets of world-time pairs, generalizing the notion of left-boundedness[15] and saying that B is instantiated in world w, $\mathit{Inst}_w(B)$, if for some t, $B.\langle w, t\rangle$. As a first step, let us relativize *earliest* to the world of evaluation as in (44) and adapt the truth conditions in (39) as in (45), assuming $\mathit{earliest}_w$ to be defined.

(44) $\quad \mathit{earliest}_w.X = \mathit{earliest}.\lambda t.X.\langle w, t\rangle$

(45) $\quad$ 'A before B' is true in w iff $(\exists t : \langle w, t\rangle \in A)\ t < \mathit{earliest}_w.B$
'A after B' is true in w iff $(\exists t : \langle w, t\rangle \in A)\ t > \mathit{earliest}_w.B$

Next, let us relativize *earliest* to a set of worlds as in (46) and specify the truth conditions as in (47), taking $\mathit{earliest}_{alt(w,t)}$ to be defined.

(46) For any set W of worlds, $\textit{earliest}_W.X = \textit{earliest}.\lambda t.(\exists w \in W)\ X.\langle w, t\rangle$[16]

(47) 'A before B' is true in w iff $(\exists t : \langle w, t\rangle \in A)\ t < \textit{earliest}_{\textit{alt}(w,t)}.B$
'A after B' is true in w iff $(\exists t : \langle w, t\rangle \in A)\ t > \textit{earliest}_{\textit{alt}(w,t)}.B$

The truth conditions in (47) relativize *earliest* to a non-empty set of worlds determined by the world of evaluation and a time at which the main clause holds. Now the task is to specify what those worlds ought to be. The idea is to have $\textit{alt}(w, t)$ consist of worlds that are maximally similar to w for as long in their history as possible and still allow for t to be a non-A time. If B is instantiated in w, then $\textit{alt}(w, t) = \{w\}$. Otherwise, we consider alternatives of w that are indistinguishable from w up to, but not including, time t, allowing for t to be a non-A time.

Following Thomason (1984), we can fix, for every time t, an equivalence relation $\simeq_t$ on the set of worlds such that if $w \simeq_t w'$ and $t' < t$, $w \simeq_{t'} w'$. Any w' such that $w' \simeq_t w$ is indistinguishable from w at all times $t' < t$ and may differ from it only from t onwards. These are the *historical alternatives* of w relative to time t. We assume that for any w, t, $\textit{alt}(w, t)$ satisfies the two conditions below.

Initial branch point condition: $\textit{alt}(w, t) \subseteq \{w' \mid w \simeq_t w'\}$.

Normality condition: $\textit{alt}(w, t)$ contains only those historical alternatives of w at t which are reasonably probable given the course of events up to t.

The initial branch point condition is meant to capture the idea that $\textit{alt}(w, t)$ contains worlds which are indistinguishable from w for as long as possible and still allow for t to be a non-A time. The normality condition constrains the alternatives to be those in which B has a reasonable chance of happening given the (causal) history of w as it has been up to t (w itself may be a world in which B happens against all odds but in that case $\textit{alt}(w, t) = \{w\}$). What is reasonably probable depends on the context so *alt* is dependent on an implicit, contextually fixed parameter as well.

The asymmetry between *before* and *after* now follows without lexical stipulation. In intuitive terms, A and B have to be on the same branch in the case of *after* but they can be on different branches in the case of *before*. Suppose B is not instantiated in the world of evaluation w and A holds of $\langle w, t\rangle$. In the case of *A before B*, backtracking in time to allow for possible futures in which t is a non-A time may produce worlds in which B is instantiated. In the case of *A after B*, B has to be instantiated in the past of t. If B is not instantiated at times earlier than t in the world of evaluation, then it is not instantiated at such times in any of the other alternatives either. The fact that B is not instantiated at times earlier than t is *historically necessary* in that case. The initial branch point condition is crucial in keeping A and B on the same branch in the case of *after*; if the branching were allowed to happen at times earlier than t, then A and B could be on different branches.[17]

The truth conditions in (47) and the way of determining the set of worlds to which *earliest* is relativized do not depend on fixing a reading in advance. The different readings of *before* are a reflection of the information in the context in which a *before* sentence is uttered and the sentence's truth conditional content. In the following discussion, let us identify contexts with their common ground, construed as

a set of worlds. In the update of a context with a sentence, the truth conditions are checked pointwise for each world in the context; worlds in which the sentence is true are retained and worlds in which it is false or has no truth value are discarded.[18]

Any context consistently updated with *A after B* will entail that B is instantiated, given that worlds in the input context in which the temporal clause is not instantiated will not be in the updated context. Hence, the sentence will only have a veridical reading. By contrast, consistently updating a context c with *A before B* will result, depending on properties of c, in a context c' which can have one of the following three kinds of mutually exclusive properties regarding B's instantiation:

(48)
Veridical $(\forall w \in c')\ \mathit{Inst}_w(B)$
Counterfactual $(\forall w \in c')\ \neg\mathit{Inst}_w(B)$
Non-committal $((\exists w \in c')\ \mathit{Inst}_w(B)) \wedge ((\exists w \in c')\ \neg\mathit{Inst}_w(B))$

The three cases in (48) correspond to the three readings of *before*. We can thus characterize the veridical and non-veridical readings of *before* sentences in terms of the entailments of particular types of contexts when updated with such a sentence. Given the meaning of a *before* sentence, the output context c' will always also satisfy the condition in (49) (trivially in the case of the veridical reading).

(49) $(\forall w \in c')\ \neg\mathit{Inst}_w(B) \rightarrow (\exists t : A.\langle w, t\rangle)(\exists w' \in \mathit{alt}(w, t))\ \mathit{Inst}_{w'}(B)$

In order for a non-veridical reading to arise, the input context has to have the necessary kind of information so that at least some of the worlds in which B is not instantiated are guaranteed to have alternatives of the kind discussed above in which B is instantiated.

For the counterfactual reading, the input context has to entail that A's occurrence makes B's later occurrence impossible and that prior to A's occurrence there was a process that made B's occurrence at least reasonably probable. The input context may contain additional information and, depending on what that is, a *before* sentence can be informative in different ways. Our account makes it possible to specify how a *before* sentence is informative relative to a particular kind of context. Consider (40), for instance, uttered in a context c as described earlier. We can take c to be partitioned into three sets of worlds. W_1 is a set of worlds in which Mozart finishes the Requiem before he dies. W_2 is a set of worlds in which Mozart does not finish the Requiem before dying, but whose normal historical alternatives contain some worlds in which he dies at a later time and he finishes the Requiem before dying. W_3 is a set of worlds in which Mozart does not finish the Requiem before the time of his actual death, and whose normal historical alternatives contain only worlds in which he dies at a later time but still does not finish the Requiem before dying. Updating c with (40) results in W_2. The worlds in W_1 drop out because they falsify (40), and the worlds in W_3 drop out because they fail to assign (40) a truth value. (40) is then informative in two ways: in excluding worlds in which Mozart finished the Requiem before dying, as well as worlds in which he would not have finished it even if he had lived longer than he actually did.

In the non-committal reading A and B are independent; allowing for A to be uninstantiated has a bearing on B's instantiation. But if there is a presupposition that at some point in the past B was likely, this would guarantee that B can be instantiated in some of the reasonably probable historical alternatives, which, in this case, are also epistemic alternatives of what the actual course of events may have been.

The veridical reading is the default option on our analysis. It will arise when the input context does not have any of the necessary properties for a non-veridical reading to arise. The context simply needs to be consistent with A being instantiated before the earliest time at which B is.

Finally, examples like (32) are odd because they cannot lead to a consistent update in any context with common sense assumptions about what is reasonably probable: not only did David not win in what we take to be the actual world, but also he could not have won in any of the reasonably probable historical alternatives in which he ate no ketchup.

7. Conclusion

We have proposed a uniform account of *before* and *after* sentences that is consistent with their differences with respect to inferential properties, NPI licensing and veridicality. We have remained neutral in this paper about whether the operator associated with the temporal clause, *earliest*, is specified in the lexical meaning of the connectives or in the process of compositional build-up through type shifting operations, as either option is compatible with our main claims.

We have shown that the meaning of the connectives need not involve distinct quantifiers and that the operator *earliest* can give the universal effect to *before*, necessary to capture its inferential and NPI licensing properties, while allowing for the existential effect of *after*. Giving *after* a semantics that is stronger than what it apparently requires, that is making use of *earliest* rather than of existential quantification, does not make it equivalent to *before* either in terms of its inferential properties or in terms of NPI licensing.

Finally, we have shown that uniformity is not only consistent with the asymmetry in veridicality between the two connectives but it can also lead to a more principled explanation for it and a more adequate analysis of veridical and non-veridical readings of *before*.

Endnotes

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1. NPI licensing by *before* and *after* is discussed by Higginbotham (1988), Land-

man (1991) and Valencia et al. (1992). Higginbotham does not regard it as an argument against converseness, although there remain unexplained differences between his analyses of *before* and *after*, and these differences seem to us to amount to the same non-uniformity that is found in Anscombe's proposal.

2. *Liverpool 1 Southampton 1*, ESPN Soccer.

3. D. Darlington, LISTOFFUN Digest 45.

4. F. Chester, *Jones, Bangles and Beatles tribute highlight San Diego music this week*, La Jolla Light 10-1-2001.

5. But see Wulf (2000) for a claim that *after* also has non-veridical readings.

6. Dennis Cauchon, *Newspapers' recount shows Bush prevailed*, *USA Today*, 5-15-2001.

7. *FARC bike bomb kills 5, injures 2*, 11-27-2002.

8. DeAnn Rossetti, *Requiem for Sept. 11 - Parce will lead Island in worldwide 'Rolling Requiem'*, 9-5-2002, Mercer Island Reporter.

9. Heinämäki's use of the operator I to pick out the first time in an interval would seem to require a similar assumption.

10. With regard to our argument that *before* and *after* could be lexical converses, note that such authors as von Stechow (2002) assume such an analysis. But neither von Stechow nor other researchers taking this position account for any of the data that motivated Anscombe and others to depart from this intuitively appealing view.

11. Heinämäki and Ogihara call the veridical reading 'factual' and the counterfactual reading 'non-factual'.

12. Heinämäki and Ogihara claim that a *would* counterfactual is always implied but it seems to us that in the absence of any further contextual assumptions the weaker *might* counterfactual is implied.

13. The discussion in Heinämäki (1972;145–146) seems to confound these two cases.

14. This extra asymmetry would imply, for instance, that (2) *entails* that Cleo left Europe, while (1) *presupposes* that David left Europe.

15. A set $W \times T$ of world-time pairs is left-bounded in its right projection iff for any $w \in W$, $\{t \mid \langle w, t\rangle \in W \times T\}$ is left-bounded.

16. Existential quantification over the set of alternatives is consistent with the implication of a *might* counterfactual in the counterfactual reading. Evidence from measure phrases may argue in favor of universal quantification instead. For the sake of concreteness, we have opted for existential quantification here, postponing discussion of the issues that may bear on the choice for another occasion. We should point out, in any case, that quantifying universally over the set of alternatives would not affect the consequences of our proposal as regards the asymmetry of the connectives in veridicality or the characterization of the various readings of *before*.

17. The veridicality of *after* and its asymmetry with *before* are thus related, on our proposal, to the asymmetry of counterfactual dependence and the impossibility of plain backtracking counterfactuals, discussed in Lewis (1979). Frank (1997) provides an account of the asymmetry of counterfactual dependence in terms of historical necessity and a minimal precedence condition in determining counterfactual alternatives, which relates to our initial branch point condition.

18. A non-standard aspect of our proposal is that we have not made the semantic definedness conditions of *earliest* into a pragmatic presupposition of the connectives.

References

Anscombe, G. E. M.: 1964, Before and after, *The Philosophical Review* **74**, 3–24.

Beaver, D. and Condoravdi, C.: 2003, 'Before' and 'After': a fragment. Available at ⟨montague.stanford.edu/~dib/Publications/salt13ho.pdf⟩.

Fauconnier, G.: 1975, Polarity and the scale principle, *Chicago Linguistics Society*, Vol. 11, pp. 188–199.

Frank, A.: 1997, *Context dependence in modal constructions*, PhD thesis, Universität Stuttgart.

Heinämäki, O.: 1972, Before, *Papers from the 8th Regional Meeting of the Chicago Linguistic Society*, University of Chicago, pp. 139–151.

Heinämäki, O.: 1974, *Semantics of English Temporal Connectives*, PhD thesis, University of Indiana at Bloomington.

Higginbotham, J.: 1988, Is semantics necessary?, *Proceedings of the Aristotelian Society* **87**, 219–241.

Hinrichs, E.: 1986, Temporal anaphora in discourses in English, *Linguistics and Philosophy* **9**, 85–112.

Ladusaw, W.: 1979, *Polarity Sensitivity as Inherent Scope Relations*, PhD thesis, University of Texas at Austin.

Landman, F.: 1991, *Structures for Semantics*, Kluwer, Dordrecht.

Lewis, D.: 1979, Counterfactual dependence and time's arrow, *Noûs* **13**, 455–476.

Ogihara, T.: 1995, Non-factual before and adverbs of quantification, *in* T. Galloway and M. Simons (eds), *Proceedings from Semantics and Linguistic Theory V*, DMLL Publications, Cornell University, Ithaca, New York, pp. 273–291.

Thomason, R. H.: 1984, Combinations of tense and modality, *in* D. Gabbay and F. Guenthner (eds), *Handbook of Philosophical Logic: Extensions of Classical Logic*, Reidel, Dordrecht, pp. 135–165.

Valencia, V. S., van der Wouden, T. and Zwarts, F.: 1992, Polarity and the flow of time, *in* A. de Boer, J. de Jong and R. Landeweerd (eds), *Language and Cognition 3*, Uitgeverij Passage, Groningen, pp. 209–218.

von Stechow, A.: 2002, Temporal prepositional phrases with quantifiers: Some additions to Pratt and Frances (2001), *Linguistics and Philosophy* **25**, 755–800.

Wulf, D. J.: 2000, *The imperfective paradox in the English progressive and other semantic course corrections*, PhD thesis, University of Washington.