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ORIGINAL RESEARCH

What if, and when? Conditionals, tense, and branching time

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Abstract
Indicative conditionals with present tense antecedents can have 'shifted' readings that are unexpected given the semantic behavior of the tenses outside of conditionals. In this paper, we compare two accounts of this phenomenon due to Kaufmann (J Semant 22(3):231–280, 2005) and Schulz (SALT XVIII, pp. 694–710, 2008), by reconstructing them in the framework of branching time. We then propose a novel account of indicative conditionals based on the branching time semantics suggested in Rumberg (J Logic Lang Inf 25(1):77–108, 2016), viz. transition semantics. We show that not only is the account of 'shifted' readings with present tense antecedents within this semantics very natural, but it also is empirically superior to its rivals in some respects.

Keywords Conditionals · Tense · Branching time · Transition semantics

1 Introduction

Even though there is a wealth of formal-semantic literature on the interpretation of conditional sentences on the one hand, and on the interpretation of the tenses on the other, there is surprisingly little work on the interaction of these phenomena, in particular with respect to indicative conditionals. This is so despite the fact that the interpretation of the tenses in indicative conditionals is quite intricate. Most notably, indicative conditionals with present tense antecedents can have 'shifted' readings that are unexpected given the semantic behavior of the tenses outside of conditionals.

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In this paper, we contribute to the nascent literature on this topic. We survey the two existing articulated proposals: Kaufmann (2005) and Schulz (2008).[1] To facilitate their comparison, with each other and with our account, we reconstruct them in the framework of *branching time*, bringing out close parallels with the two classic branching time semantics, Ockhamism and Peirceanism. We then propose a novel account of the temporal interpretation of indicative conditionals based on the more recent *transition semantics* for branching time suggested in Rumberg (2016).

Throughout, we focus on indicative 'bare' conditionals containing 'simple tenses'. That is, we set aside: (i) subjunctive or 'X-marked' conditionals, (ii) conditionals containing overt modals, and (iii) conditionals including future *will*, the perfect, or the progressive. We also set aside generic or 'multi-case' conditionals that express a regularity or a law, focussing instead on 'one-case' conditionals that pertain to particular situations. We limit ourselves in this way to keep the discussion focussed, acknowledging that, ultimately, it is desirable to have a uniform analysis of all these phenomena. As we will see, even with our limited focus, there is quite some complexity to deal with.

2 The empirical picture

In this section, we lay out our view of the pertinent data, drawing mainly on Crouch (1993, 1994), to whom we owe the main empirical observations, as well as on Kaufmann (2005) and Schulz (2008).

2.1 Past and present tense in non-conditional sentences

An isolated past tense sentence locates the described event before the evaluation time of the sentence, which defaults to the speech time. Thus, (1) locates John's leaving before the evaluation/speech time.

(1) John left at five.

An isolated present tense defaults to expressing simultaneity with the evaluation/speech time:[2]

(2) John is ill.

However, the present tense can also be interpreted as future-oriented. The future-orientation can be triggered by temporal adverbs or (strong) contextual clues:

(3) John is in Rome two weeks from now / when Mary is there.

[1] Besides the works cited in the main text, the only substantive works on the temporal interpretation of indicative conditionals that we know of are Copley (2008) and Grønn and von Stechow (2011), who, however, do not give accounts of the 'shifted' readings we are interested in here.

[2] Strictly speaking, this is only true for sentences involving *stative* predicates. With a few principled exceptions, *eventive* predicates in the simple present do not express simultaneity but can only be used to talk about future events and hence are always subject to the 'settledness' constraints we are about to discuss.

This kind of future-orientation is quite restricted. It is available only if the future eventuality is intended or planned (as in (3)), accords with a schedule (4), or is taken to be already predetermined (5).[3]

(4) The train from Utrecht arrives at 7:46 p.m.

(5) The sun rises at 6:43 a.m. tomorrow.

For a minimal pair illustrating this constraint, consider (6).

(6) a. The Red Sox play the Yankees tomorrow.
b. #The Red Sox beat the Yankees tomorrow.

(6a) is unexceptional and says that the Red Sox are scheduled to play the Yankees tomorrow. (6b), on the other hand, is infelicitous under normal conditions, because, normally, the outcome of the game is neither planned, scheduled, nor predetermined. The sentence becomes acceptable, however, if we are in a context where the Mafia is fixing the game—precisely because then the outcome of the game can be considered planned, scheduled, or predetermined.

2.2 Conditionals with past tense antecedents…

If the antecedent of an indicative conditional contains the morphological past tense, this past tense is interpreted just as it would be interpreted in an isolated sentence. That is, just as (1) locates John's leaving before the evaluation/speech time, (7) makes a hypothesis about John leaving before the evaluation/speech time.[4]

(7) If John left at five, …

2.2.1 . . . with past tense consequents

If the consequent stands in the past tense as well, the consequent event is likewise located before the evaluation/speech time. No additional constraints are imposed on the relative location of the respective antecedent and consequent event times.

(8) a. If John left at five, he arrived at six.
antecedent event $<$ *consequent event*
b. If John arrived at six, he left at five.
antecedent event $>$ *consequent event*

[3] These observations are not at all novel, of course. They entered the formal linguistics literature in the 1970s (e.g. Lakoff, 1971; Vetter, 1973; Goodman, 1973; Dowty, 1979). For a recent, articulated perspective on futurate uses of the simple present and present progressive, see Copley (2009).

[4] There are apparent counterexamples to this generalization, which is originally due to Crouch (1993, 1994). An anonymous reviewer pointed out sentences like the following:

(i) Call John's secretary tomorrow evening to find out when he's coming. If he left at five, he will arrive on time.

In this example, the past tense antecedent refers to a future time. We take it that here the past tense is licensed by a deictic shift akin to modal subordination, which is triggered by the imperative in the preceding discourse context (Asher and Lascarides, 2003; Schwager, 2006, Ch. 3.1.1; Kaufmann, 2012, Ch. 2.2.3). We set aside such cases in this paper, but briefly return to them in Sect. 4.3.

2.2.2 …with present tense consequents

In conditionals with past tense antecedents, a present tense in the consequent is also interpreted exactly as it is in isolation: it either expresses simultaneity with the evaluation/speech time (9), or it locates the consequent event in the future of the evaluation/speech time, which requires that the eventuality is planned, scheduled, or predetermined (10).

(9) If the offer letter was sent on time, Mary knows about it (now).

(10) If the team did not get injured in yesterday's freak accident, …

a. …the Red Sox play the Yankees tomorrow.

b. #…the Red Sox beat the Yankees tomorrow.
(fine if the game is fixed)

2.3 Conditionals with present tense antecedents…

So far, the interpretation of the tenses in conditionals has been unsurprising: tenses in indicative conditionals with past tense antecedents are interpreted exactly as they are in isolated sentences. The situation changes, however, once we turn to conditionals with present tense antecedents.

First of all, simple present in the antecedent of a conditional allows for future reference without any requirement for planning, scheduling, or predetermination.

(11) If the Red Sox beat the Yankees tomorrow, ….

This indicates that the conditional structure 'opens up' the future beyond the usual possibility for future-oriented present tense.[5]

2.3.1 …with past tense consequents

What is more, when the present tense in the antecedent receives a future interpretation, there is a reading where the consequent tense is 'dependent' on the antecedent tense: the consequent tense locates the consequent event not to the evaluation/speech time of the conditional, but instead locates it to a later time. This is the case in Crouch's (1993) classic (12).

(12) [Context: The speaker has an important job interview tomorrow. The addressee will wait for the speaker outside.]

If I smile when I get out, the interview went well.

[5] This is reminiscent of the way modal auxiliaries 'open up' the time-frame of their infinitive complements towards the future (Condoravdi, 2002):

(i) The Red Sox must beat the Yankees tomorrow.

In (12), both the antecedent event (the smiling) and the consequent event (the interview) are in the future of the speech situation. And yet, the consequent stands in the past tense, intuitively marking the fact that the interview precedes the smiling event. The past tense in the consequent gets a shifted 'past-in-the-future' interpretation.

2.3.2 …with present tense consequents

We note in passing that conditionals with present tense consequents can get shifted readings as well when the present tense in the antecedent refers to the future, as in (13).

(13) (I sent you the final paperwork.) If you sign it, the house is yours.

However, we will set these cases aside for most of this paper. One reason for this is that these shifted future readings of the present tense in the consequent are subject to restrictions we do not understand well at present. For example, it is unclear why (14) is quite odd and (15) must be used instead.[6]

(14) ?If John passes his oral exam tomorrow, he is happy (then).

(15) If John passes his oral exam tomorrow, he will be happy (then).

2.4 Four questions concerning tense and conditionals

The empirical data outlined above suggests that a theory of tense and indicative conditionals should (at least) answer the following four questions:

(i) Why is future reference with the present tense in isolated sentences only possible if the eventuality talked about is planned, scheduled, or predetermined?
(ii) Why is this constraint obviated when the present tense occurs in the antecedent of an indicative conditional?
(iii) How does it come about that the consequent tense can get a shifted interpretation in conditionals with present tense antecedents?
(iv) Why are such shifted readings impossible with past tense antecedents?

These four questions will guide our investigation throughout this paper. They will serve as evaluation criteria in our assessment of the accounts proposed in Kaufmann (2005) and Schulz (2008), and they constitute the empirical basis of our own proposal.

Besides the limitations of scope that we introduced in Sect. 1, we restrict ourselves here to an 'ontic' ('metaphysical' or 'historical') reading of conditionals, acknowledging that indicative bare conditionals likely have additional readings; most notably, epistemic or doxastic ones. Since much of the paper focuses on ontic conditionals with future-oriented present tense antecedents, it is useful to have a short name for these kinds of sentences, and we refer to them as *predictive conditionals*.[7]

[6] Kaufmann has suggested (p.c.) that the contrast between (14) and (15) can be explained on his account, where *will* expresses a weaker kind of necessity than the bare present tense. Yet, we remain uncertain whether the difference between (14) and (15) should be explained in terms weak versus strong necessity, rather than in terms of, for example, analyticity versus causality, or simultaneity versus temporal abutment.

[7] We take the term from Kaufmann (2005) but use it in a more restricted sense. Kaufmann (2005) also includes some epistemic/doxastic conditionals under this heading.

At the very heart of our account of the temporal interpretation of ontic conditionals—as in Kaufmann's and Schulz's—is the idea that there is a fundamental ontological asymmetry between the past and the future: while the past is fixed, the future is genuinely open. That is to say, there are alternative future possibilities. Against this ontological background, planned, scheduled, and predetermined eventualities are conceptualized as 'settled', where settledness is to be understood as 'historical necessity', i.e. necessity given the actual past course of events up to the present. This assumption becomes crucial in the interpretation of the futurate present tense, both in isolated and in conditional sentences.

2.5 Overview

The rest of this paper is structured as follows: in Sect. 3, we introduce the theory of branching time as a useful representation of the open future and briefly discuss the two classic branching time semantics: Peirceanism and Ockhamism. In Sect. 4, we review the accounts of predictive conditionals proposed in Kaufmann (2005) and Schulz (2008) and evaluate to what extent these accounts give satisfactory answers to the four questions stated above. In order to facilitate comparison, we reconstruct them in the branching time framework. We will see that Kaufmann's account corresponds to an Ockhamist semantics, whereas Schulz's account is in essence a Peircean one. In Sect. 5, we then propose a novel analysis of predictive conditionals based on Rumberg's (2016) transition semantics for branching time and show how our approach solves certain shortcomings of the accounts developed in Kaufmann (2005) and Schulz (2008). In Sect. 6, we conclude with some open questions that remain.

3 The theory of branching time

In the interpretation of predictive conditionals, the idea that the future is open plays a pivotal role: indicative conditionals with future-oriented present tense antecedents allow unconstrained reference to the open future, taking away the settledness requirement that usually accompanies the futurate present tense.

The three accounts that we discuss in this paper rely on different frameworks to formally represent the openness of the future. Kaufmann's (2005) account of predictive conditionals builds on the so-called $T \times W$ framework, whereas Schulz's (2008) proposal makes use of partial interpretation functions. We ourselves will draw on the theory of branching time, which offers a unifying framework. In this section, we introduce the notion of a branching time structure and go over the traditional Peircean and Ockhamist branching time semantics, in which Kaufmann's and Schulz's accounts will be reconstructed. In Sect. 5, we discuss a third, more recent, branching time semantics, viz. Rumberg's (2016) transition semantics, on which our account is based.[8]

[8] We keep our exposition of the theory of branching time brief. For a more detailed overview, see Goranko and Rumberg (2020).

3.1 Branching time structures

The theory of branching time, pioneered by Prior (1967), provides a natural formal representation of the ontological asymmetry between the fixed past and the open future. The modal-temporal structure of the world is depicted as a tree that is linear towards the past and branches into multiple possible futures. Formally, a *branching time structure* is a non-empty set of moments M together with an earlier-later relation $\lhd$ that is required to be *left-linear* and *connected*.

Definition 1 *(Branching time structures)* A *branching time structure* is a pair $\mathcal{M} = \langle M, \lhd \rangle$ where M is a non-empty set of moments and $\lhd$ is a strict partial order on M such that

(i) for all $m_1, m_2, m_3 \in M$, if $m_1 \lhd m_3$ and $m_2 \lhd m_3$, then $m_1 \lhd m_2$, $m_1 = m_2$, or $m_1 \rhd m_2$ (left-linearity);
(ii) for all $m_1, m_2 \in M$, there is some maximal $m_0 \in M$ such that $m_0 \trianglelefteq m_1$ and $m_0 \trianglelefteq m_2$ (connectedness).[9]

The first condition is what captures the fundamental asymmetry between the past and the future: it rules out backward branching. Every moment has a linear past, while there may be $\lhd$-incomparable moments in its future. The second condition guarantees historical connectedness: any two moments share some common past, up to a branching point. An example of a branching time structure is provided in Fig. 1.

Despite its name, a branching time structure is not supposed to represent time. Rather, it depicts alternative possible temporal developments of the world in a unified structure, and moments are best understood as representing a possible state of the world at a time. Each maximal linear path through the tree of moments defines a *history*, i.e., it corresponds to a complete possible course of events. If all histories in a branching time structure are properly synchronized, a linear series of times can be projected onto the tree, associating different moments in different histories with the same time, as indicated in Fig. 1.

Definition 2 *(Histories)* For $\mathcal{M} = \langle M, \lhd \rangle$ a branching time structure, a *history* is a maximal $\lhd$-linear subset h of M (i.e., for all $m_1, m_2 \in h$, we have $m_1 \lhd m_2, m_1 = m_2$, or $m_1 \rhd m_2$, and there is no proper superset $h' \supsetneq h$ in M that has this property). Given a moment $m \in M$, we denote the set of histories passing through m by $\mathsf{Hist}(m)$.

3.2 Branching time semantics

Branching time structures are primarily employed in the semantics of formal languages containing temporal operators P and F for the past and the future, and/or a modal operator $\Box$ for settledness. The truth values of complex sentences are defined recursively, given a valuation of the propositional variables in a model.

[9] The requirement that any two moments have a *greatest* common lower bound is optional in the theory of branching time. We impose it here to guarantee the existence of branching points, which are crucial in transition semantics.

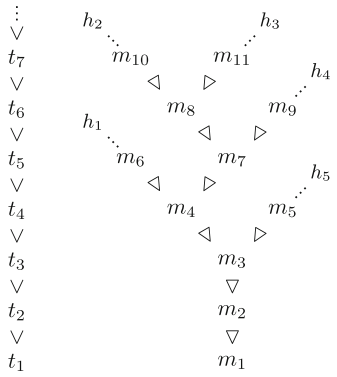


Fig. 1 A branching time structure associated with a linear series of times

In what follows, let *Prop* be our set of propositional variables. One natural way to think about propositional variables in branching time is to view them as atomic sentences that describe the fundamental facts holding at a moment in the tree. Accordingly, the valuation in a *branching time model* assigns truth values to the propositional variables relative to moments.

Definition 3 *(Branching time models)* A *branching time model* $\mathfrak{M} = \langle M, \lhd, V \rangle$ is a branching time structure $\mathcal{M} = \langle M, \lhd \rangle$ together with a valuation function $V : M \to (Prop \to \{0, 1\})$.

In the theory of branching time, a context of utterance uniquely fixes the moment at which the utterance takes place. Because of the absence of backward branching, this moment determines a unique past, while there may be various branches leading towards the future. The semantics of the past operator P is thus straightforward: what 'has been the case' is what is true in the actual past. Spelling out truth conditions for the future operator F is more intricate, as there is no actual future. Rather, each of the branches leading towards the future represents a future possibility, and, as of now, it is indeterminate which of these possibilities will become actual as time progresses. There are different options how to deal with the absence of an actual future semantically: the different proposals essentially make use of different parameters of truth.

3.2.1 Peirceanism

In the Peircean semantics, sentences are evaluated from the local standpoint of a moment in the tree, and future truth requires settledness: what 'will be the case' is what is true in every possible future.

(Past) $\mathfrak{M}, m \vDash \mathsf{P}_\mathsf{p}\varphi$ iff there is some moment m' such that $m' \lhd m$ and $\mathfrak{M}, m' \vDash \varphi$;
(Future) $\mathfrak{M}, m \vDash \mathsf{F}_\mathsf{p}\varphi$ iff for all histories $h \in \mathsf{Hist}(m)$, there is some moment $m' \in h$ such that $m' \rhd m$ and $\mathfrak{M}, m' \vDash \varphi$.

3.2.2 Ockhamism

In the Ockhamist semantics, sentences are evaluated at pairs m/h consisting of a moment m and a history $h \in \mathsf{Hist}(m)$ passing through that moment. What 'will be the

case' is what is true in the given history, and a modal operator for settledness becomes interpretable as a universal quantifier over histories. Future truth and settledness come apart.[10]

(Past) $\mathfrak{M}, m/h \vDash \mathsf{P}_{\mathsf{o}}\varphi$ iff there is some moment m' such that $m' \lhd m$ and $\mathfrak{M}, m'/h \vDash \varphi$;

(Future) $\mathfrak{M}, m/h \vDash \mathsf{F}_{\mathsf{o}}\varphi$ iff there is some moment $m' \in h$ such that $m' \rhd m$ and $\mathfrak{M}, m'/h \vDash \varphi$;

(Settled) $\mathfrak{M}, m/h \vDash \Box_{\mathsf{o}}\varphi$ iff for all histories $h' \in \mathsf{Hist}(m)$, $\mathfrak{M}, m/h' \vDash \varphi$.

It is worthwhile to note that, unlike the moment parameter, the Ockhamist history parameter is not fixed by a context of utterance. If the future is genuinely open, the context of utterance cannot single out one of the histories passing through the moment of utterance as 'the actual history', as there is no actual future.

4 Conditionals in Kaufmann (2005) and Schulz (2008)

In this section, we discuss and evaluate the accounts of predictive conditionals proposed in Kaufmann (2005) and Schulz (2008). Their proposals crucially differ with respect to how they formally represent the open future. Nonetheless, both of them can be reconstructed in the theory of branching time. This allows us to bring out their similarities and dissimilarities more clearly and facilitates comparison with our own proposal. Moreover, the reconstruction brings to light that at the cores of the accounts put forth in Kaufmann (2005) and Schulz (2008) are the competing views underlying the Ockhamist and Peircean branching time semantics, respectively.

Before we turn to Kaufmann's and Schulz's accounts of the temporal interpretation of predictive conditionals, however, a general remark on the semantics of indicative conditionals is in order. The standard analysis follows Kratzer's (1979, 1981) basic recipe: the consequent of indicative bare conditionals is assumed to contain a covert necessity operator, which is associated with a modal base, and the antecedent is interpreted as a restrictor on the respective set of possibilities.[11] That is, an indicative conditional is true iff all relevant antecedent possibilities are consequent possibilities. If we think of possibilities as possible worlds, Kratzer's basic recipe can be formulated as follows:

Definition 4 *(Kratzer's basic recipe for conditionals)*

$$\begin{aligned} &\mathfrak{M}, w \vDash \text{If } A, \text{ then } [\mathsf{NEC}]_{\mathrm{MB}} C \\ &\qquad\qquad \text{iff} \\ &\text{for all } w' \in \mathsf{Poss}_{\mathrm{MB}}(w, A), \text{ we have } \mathfrak{M}, w' \vDash C \end{aligned}$$

where $\mathsf{Poss}_{\mathrm{MB}}(w, A) = \{w' \mid w R_{\mathrm{MB}} w' \text{ and } \mathfrak{M}, w' \vDash A\}$.

[10] Note that, since the valuation in a branching time model depends only on the moment parameter, for the propositional variables $Q \in \mathit{Prop}$, we have: $\mathfrak{M}, m/h \vDash Q$ iff $\mathfrak{M}, m/h \vDash \Box_{\mathsf{o}} Q$.

[11] To distill the essence of Kratzer's basic recipe, we here omit the second parameter that Kratzer uses in her own account, viz. the ordering source.

Naturally the question arises: how does tense enter the picture? What are the relevant antecedent possibilities in the case of ontic temporal conditionals? In particular, how can we account for the shifted readings of indicative conditionals with futurate present tense antecedents?

4.1 Kaufmann's (2005) account of conditionals

In this section, we discuss Kaufmann's (2005) account, proceeding in three steps: first, we provide the theoretical background of his proposal, second, we discuss his analysis of predictive conditionals, and third, we reconstruct his account in an Ockhamist branching time semantics.

4.1.1 Theoretical background: the T × W framework

The account of predictive conditionals proposed in Kaufmann (2005) is based on the notion of a $T \times W$ *frame*: possible worlds are combined with a linearly ordered set of times and a *historical accessibility relation* (cf. Thomason, 1984).[12] An example of a $T \times W$ frame is provided in Fig. 2.

Definition 5 *($T \times W$ frames)* A $T \times W$ *frame* is a quadruple $\mathcal{F} = \langle W, T, <, \approx \rangle$ where

(i) W is a non-empty set of possible worlds;
(ii) T is a non-empty set of times;
(iii) $<$ is a strict linear order on T;
(iv) $\approx \subseteq T \times W \times W$ is a relation such that

(a) for all $t \in T$, the relation $\approx_t \subseteq W \times W$ is an equivalence relation;
(b) for all $w_1, w_2 \in W$ and for all $t, t' \in T$, if $w_1 \approx_t w_2$ and $t' < t$, then $w_1 \approx_{t'} w_2$.

In $T \times W$ frames, the ontological asymmetry between the fixed past and the open future is captured by the historical accessibility relation: possible worlds that are accessible at a given time share the same past but depict alternative future possibilities. Under this intended interpretation, two further constraints on the historical accessibility relation $\approx$ seem quite natural:

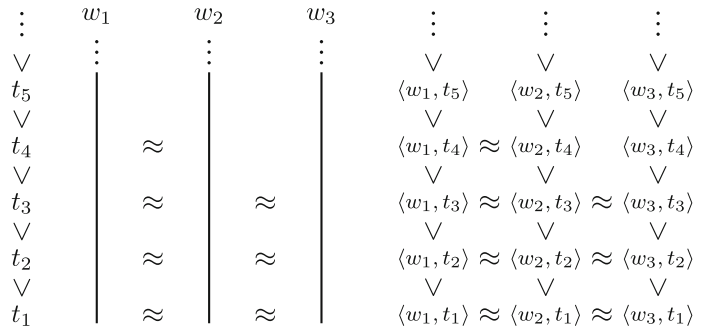
(iv.c) for all $w_1, w_2 \in W$, there is some maximal $t \in T$ such that $w_1 \approx_t w_2$;
(iv.d) for all $w_1, w_2 \in W$, if $w_1 \neq w_2$, there is some $t \in T$ such that $w_1 \not\approx_t w_2$.

While the first condition guarantees historical connectedness, by requiring that any two possible worlds are accessible at some time,[13] the second condition ensures historical distinctness, by ruling out that two worlds are accessible at all times.

In a $T \times W$ frame $\mathcal{F} = \langle W, T, <, \approx \rangle$, sentences are evaluated at world-time pairs $\langle w, t \rangle$. Thus, the set of indices is $W \times T$, and the relations $<$ and $\approx$ can be

[12] The relevant definitions concerning the $T \times W$ framework in Kaufmann (2005) are Defs. 1–3 in Sect. 2.1.

[13] The requirement of maximality in condition (iv.c) is the analogue of the maximality requirement in condition (ii) of the definition of a branching time structure, which guarantees the existence of branching points.



(a) A $T \times W$ frame. (b) The set of indices.

Fig. 2 The $T \times W$ framework

straightforwardly transferred to that set, as illustrated in Fig. 2.[14] For all $\langle w_1, t_1\rangle$, $\langle w_2, t_2\rangle \in W \times T$:

$(<)$ $\langle w_1, t_1\rangle < \langle w_2, t_2\rangle$ iff $w_1 = w_2$ and $t_1 < t_2$;
$(\approx)$ $\langle w_1, t_1\rangle \approx \langle w_2, t_2\rangle$ iff $t_1 = t_2$ and $w_1 \approx_{t_1} w_2$.

In a model on a $T \times W$ frame, the valuation on the set of propositional variables *Prop* is constrained so that historically accessible indices make exactly the same propositional variables true. This reflects the idea that worlds that have not yet diverged share the same initial segment, i.e., they coincide with respect to the past and may only differ with respect to the future.

Definition 6 *($T \times W$ models)* A $T \times W$ *model* $\mathfrak{M} = \langle W, T, <, \approx, V\rangle$ is a $T \times W$ frame $\mathcal{F} = \langle W, T, <, \approx\rangle$ together with a valuation function $V : W \times T \to (Prop \to \{0, 1\})$ such that for all $\langle w_1, t_1\rangle, \langle w_2, t_2\rangle \in W \times T$, if $\langle w_1, t_1\rangle \approx \langle w_2, t_2\rangle$, then $V(\langle w_1, t_1\rangle) = V(\langle w_2, t_2\rangle)$.

4.1.2 Predictive conditionals in Kaufmann (2005)

We now turn to Kaufmann's (2005) temporal interpretation of predictive conditionals. One fundamental assumption of Kaufmann's account concerning tense is the idea that the morphological present tense expresses non-pastness rather than simultaneity. The meaning of the tenses is taken to be relational: tenses modify the time interval in which the respective event is to occur (cf. Kaufmann, 2005, (18), p. 248). Note that, due to the definition of $<$, the tenses only relate times within the same world.

- $[\![\text{PRESENT}]\!] = \lambda\langle w, t\rangle\lambda\langle w', t'\rangle.\ \langle w', t'\rangle \geq \langle w, t\rangle$;
- $[\![\text{PAST}]\!] = \lambda\langle w, t\rangle\lambda\langle w', t'\rangle.\ \langle w', t'\rangle < \langle w, t\rangle$.

In the $T \times W$ framework, the most straightforward approach to predictive conditionals—in line with Kratzer's basic recipe—is as follows: a predictive conditional is true at a world-time pair iff all historically accessible indices that make

[14] In Kaufmann (2005), in addition to the ontic accessibility relation $\approx$, a doxastic or epistemic accessibility relation $\sim$ is introduced, which we do not discuss here.

the tensed antecedent true, make the tensed consequent true as well. In fact, such an account was proposed in Kaufmann (2002).

Definition 7 *(Conditionals in* Kaufmann, 2002*)*

$$\begin{aligned}&\mathfrak{M}, \langle w, t\rangle \vDash \text{ If } [\mathsf{TENSE}]A, \text{ then } [\mathsf{NEC}]_{\approx}[\mathsf{TENSE}]C\\ &\qquad\qquad \text{iff}\\ &\text{for all } \langle w', t'\rangle \in \mathsf{Poss}_{\approx}(\langle w, t\rangle, [\mathsf{TENSE}]A), \text{ we have } \mathfrak{M}, \langle w', t'\rangle \vDash [\mathsf{TENSE}]C\end{aligned}$$

where $\mathsf{Poss}_{\approx}(\langle w, t\rangle, [\mathsf{TENSE}]A) = \{\langle w', t'\rangle \mid \langle w, t\rangle \approx \langle w', t'\rangle \text{ and } \mathfrak{M}, \langle w', t'\rangle \vDash [\mathsf{TENSE}]A\}$.

That is, in filling out Kratzer's basic recipe, possible worlds are replaced by world-time pairs, and the modal base is given by the historical accessibility relation.

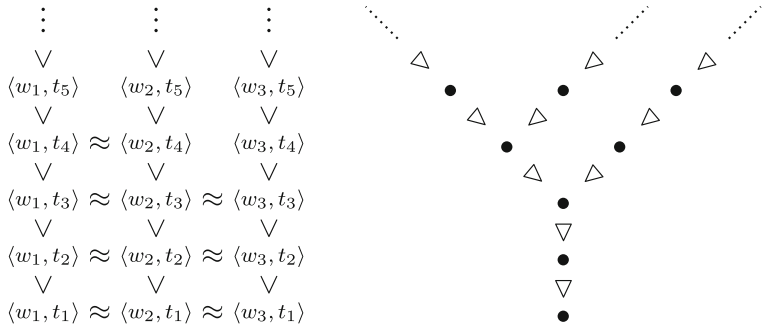
On the assumption that assertibility presupposes settledness, this analysis allows for a very simple explanation of why a futurate present tense sentence needs to be settled true when used in isolation but not when it occurs as the antecedent of a conditional: the antecedent of a conditional is not asserted. The analysis cannot, however, account for possible forward shifts of the evaluation time of the consequent: both the relevant antecedent and consequent possibilities are co-temporal with the index of evaluation/utterance. In Kaufmann (2005), the initial proposal is retracted and a modified analysis based on antecedent settledness rather than antecedent truth is offered. The basic modifications are as follows:

(1) All non-modalized sentences (past and present tense) contain a covert necessity operator. In an ontic context, this necessity operator is interpreted as a settledness operator along the historical accessibility relation. That is, the tensed antecedent is taken to be of the form '$[\mathsf{NEC}]_{\approx}[\mathsf{TENSE}]A$' (cf. Kaufmann, 2005, Sect. 4.1).
(2) The semantics of 'if' involves a relation that 'modifies' the accessibility relation underlying the necessity operator in the consequent and can trigger a forward shift. Given the historical accessibility relation $\approx$, the forward extension $\approx^*$ is defined as follows: $\langle w_1, t_1\rangle \approx^* \langle w_2, t_2\rangle$ iff there is some $\langle w_0, t_0\rangle \in W \times T$ such that $\langle w_1, t_1\rangle \approx \langle w_0, t_0\rangle$ and $\langle w_0, t_0\rangle \leq \langle w_2, t_2\rangle$ (cf. Kaufmann, 2005, Def. 9, p. 261 and (45), p. 262).
(3) The semantics of 'if' involves a contextual parameter e that constrains the possible forward shift triggered by $\approx^*$ (cf. Kaufmann, 2005, (45), pp. 262f.).

Definition 8 *(Conditionals in* Kaufmann, 2005*)*

$$\begin{aligned}&\mathfrak{M}, \langle w, t\rangle \vDash \text{ If } [\mathsf{NEC}]_{\approx}[\mathsf{TENSE}]A, \text{ then } [\mathsf{NEC}]_{\approx}[\mathsf{TENSE}]C\\ &\qquad\qquad \text{iff}\\ &\text{for all } \langle w', t'\rangle \in \mathsf{Poss}^{e}_{\approx^*}(\langle w, t\rangle, \Box_{\approx}[\mathsf{TENSE}]A), \text{ we have } \mathfrak{M}, \langle w', t'\rangle \vDash [\mathsf{TENSE}]C\end{aligned}$$

where $\mathsf{Poss}^{e}_{\approx^*}(\langle w, t\rangle, \Box_{\approx}[\mathsf{TENSE}]A) = \{\langle w', t'\rangle \mid \langle w, t\rangle \approx^* \langle w', t'\rangle \text{ and } \mathfrak{M}, \langle w', t'\rangle \vDash e_{\langle w,t\rangle} \text{ and } \mathfrak{M}, \langle w', t'\rangle \vDash \Box_{\approx}[\mathsf{TENSE}]A\}$.



(a) $T \times W$ frame. (b) Branching time structure.

Fig. 3 $T \times W$ frames and branching time structures

That is, a predictive conditional is true at a world-time pair iff the tensed consequent is true at all contextually relevant indices at which the tensed antecedent is settled, and since $\approx$ is replaced by $\approx^*$, the contextually relevant indices may now be future indices. Note that this analysis still follows Kratzer's basic recipe: antecedent possibilities are required to be consequent possibilities as well. The crucial difference with Kaufmann's (2002) account consists in the fact that the respective indices no longer have to be co-temporal with the index of evaluation/utterance. This opens up the possibility to account for shifted readings, as we will see in Sect. 4.3.

4.1.3 Kaufmann (2005) in branching time

From a technical point of view, the $T \times W$ framework, on which Kaufmann's (2005) account is based, is a close semantic counterpart of the branching time framework. In fact, every $T \times W$ frame (that fulfills the additional conditions (iv.c) and (iv.d) following Def. 5) can straightforwardly be transformed into a homomorphic branching time structure, simply by collapsing the historical accessibility relation into identity, as illustrated in Fig. 3. All $\approx$-related world-time pairs are merged into a single moment, and the ordering $\lhd$ between moments is defined so that it mirrors the ordering $<$ between the corresponding world-time pairs (cf. e.g. Reynolds, 2002). Under this transformation, times dissolve into moments, and possible worlds are mapped onto histories.[15] The construction readily extends to models as well: since in a $T \times W$ frame the valuation of the propositional variables is constant across $\approx$-related world-time pairs, it naturally carries over to the moments in the resulting branching time structure.

Kaufmann's (2005) account of the tenses and of the necessity operator can be translated into an Ockhamist branching time semantics, where sentences are evaluated at

[15] A technical complication that arises here and that we will set aside in this paper concerns the so-called *problem of emergent histories*. Recall that in the $T \times W$ framework, possible worlds are primitive entities, whereas in the theory of branching time, histories are defined in terms of moments. As a consequence, when transforming a $T \times W$ frame into a branching time structure, histories may become definable that do not correspond to any of the possible worlds. This problem can be easily remedied by moving to *bundled branching time structures*, which are branching time structures with a primitive set of histories (cf. Burgess, 1978). To keep the exposition simple, we will not explicitly perform this move here.

moment-history pairs. Recall that on Kaufmann's account, the tenses only relate times within the same world. This is in line with an Ockhamist interpretation of the temporal operators, where the moment of evaluation is shifted forwards and backwards on the given history. Moreover, the covert necessity operator, which Kaufmann assumes to be part of any non-modalized sentence, straightforwardly translates into the Ockhamist settledness operator: quantifying over all $\approx$-accessible world-time pairs in a $T \times W$ frame is tantamount to quantifying over all histories passing through the corresponding moment in the correlated branching time structure (on the proviso in footnote 15). This yields the following translations:

- $\mathsf{PRESENT}Q := Q \vee \mathsf{F}_{\mathsf{o}}Q$;
- $\mathsf{PAST}Q := \mathsf{P}_{\mathsf{o}}Q$;
- $\Box_{\approx}Q := \Box_{\mathsf{o}}Q$.

The key ingredient of Kaufmann's (2005) approach to predictive conditionals is the forward extension $\approx^*$ of the historical accessibility relation, which enters with the semantics of 'if'. This relation takes us, along historically accessible possible worlds, to a future index at which the tensed antecedent is settled (that is, true at all $\approx$-related indices). Note that in the theory of branching time, this move reduces to a future shift along the $\lhd$-relation between moments. The shift is constrained by Kaufmann's contextual parameter e, and in evaluating the consequent, all histories passing through the later moment are taken into account.[16] The analysis of predictive conditionals proposed in Kaufmann (2005) can then be reconstructed as follows in an Ockhamist branching time semantics:

Definition 9 *(Kaufmann's, 2005 conditionals in branching time)*

$$\begin{aligned}&\mathfrak{M}, m/h \vDash \text{ If } [\mathsf{NEC}][\mathsf{TENSE}]A, \text{ then } [\mathsf{NEC}][\mathsf{TENSE}]C\\ &\qquad\qquad \text{iff}\\ &\text{for all } m'/h' \in \mathsf{Poss}^{e}_{\trianglelefteq}(m/h, \Box_{\mathsf{o}}[\mathsf{TENSE}]A), \text{ we have } \mathfrak{M}, m'/h' \vDash [\mathsf{TENSE}]C\end{aligned}$$

where $\mathsf{Poss}^{e}_{\trianglelefteq}(m/h, \Box_{\mathsf{o}}[\mathsf{TENSE}]A) = \{m'/h' \mid m' \trianglerighteq m \text{ and } h' \in \mathsf{Hist}(m') \text{ and } \mathfrak{M}, m'/h' \vDash e_{m/h} \text{ and } \mathfrak{M}, m'/h' \vDash \Box_{\mathsf{o}}[\mathsf{TENSE}]A\}$.

A crucial difference remains: in the original $T \times W$ framework, the context of utterance cannot only fix the time of the utterance but also the world of the utterance. The moment-history pairs employed in the Ockhamist branching time semantics, by contrast, cannot be fully initialized in a context: while the context of utterance fixes the moment of utterance, it fails to provide an initial value for the history parameter if the future is genuinely open.

[16] We assume here that the contextual parameter e, which is formally defined as a predicate of world-time pairs, in effect is only a property of times. While this is not made explicit in Kaufmann (2005), it is strongly suggested by the prose (especially on p. 263), and Stefan Kaufmann (p.c.) confirms that this was indeed his intention.

4.2 Schulz's (2008) account of conditionals

We now turn to Schulz's (2008) analysis of the temporal interpretation of predictive conditionals. As in our discussion of Kaufmann's (2005) account, we proceed in three steps: first, we provide the theoretical background of her proposal, second, we review her approach to predictive conditionals, and third, we show that her account can be reconstructed in the theory of branching time as well—this time making use of the Peircean branching time semantics.

4.2.1 Theoretical background: partial interpretation functions

The innovative idea of the account of predictive conditionals proposed in Schulz (2008) is to model the openness of the future by means of partial interpretation functions over times. The key notion in her account is that of a *possibility*: in a nutshell, a possibility is a 'centered' partial interpretation function $\langle v, t\rangle$ that is completely defined in the past of t but may be undefined in the future of t, thus reflecting the ontological asymmetry between the fixed past and the open future.

Before we specify the notion of a possibility in full detail, we introduce some terminology and distinctions not present in Schulz's paper that we find useful for reconstructing her account: to wit, *situations*, *states*, *world fragments*, as well as the *historical t-restriction* of a world fragment.

On Schulz's account, the interpretation of the propositional variables can be incomplete in two respects: the valuation does not have to be defined at all times, and if defined at a time, it does not have to be defined there for all propositional variables. The following two definitions capture this distinction. As before, *Prop* is our set of propositional variables, T is a non-empty set of times, and $<$ is a strict linear order on T. The domain of a (partial) interpretation function f will be denoted by $Dom(f)$.

Definition 10 *(Situations and states)* A *situation* is a partial interpretation function $s : Prop \to \{0, 1\}$. A situation s is called a *state* iff $Dom(s) = Prop$. We denote the set of possible situations by S.

Definition 11 *(World fragments and worlds)* A *world fragment* is a partial interpretation function $v : T \to S$. A world fragment v is called a *world* iff (i) $Dom(v) = T$ and (ii) for all $t \in T$, $v(t)$ is a state. We denote the set of all world fragments by V.

Whereas situations and states capture partiality and completeness of the interpretation at a time, world fragments and worlds capture partiality and completeness of the interpretation over time. For practical purposes, we are often interested in only the initial segment of a world fragment up to a given time t, and this is what we call the *historical t-restriction*.

Definition 12 *(Historical t-restriction)* The *historical t-restriction* $v{\restriction}_t$ of a world fragment $v \in V$ is the partial interpretation function $v' \in V$ such that (i) $Dom(v') = Dom(v) \cap \{t' \in T \mid t' \leq t\}$ and (ii) $v' \subseteq v$.

A Schulzian possibility can now be defined as a centered world-fragment $\langle v, t\rangle$ that fulfills the following two conditions: the world fragment v assigns a state to each time

in the past of t, and it assigns a situation to a future time if and only if the respective situation is predetermined by the laws of nature given the past course of events up to t (cf. Schulz, 2008, Def. 8, p. 703).

The definition we provide below slightly differs from the one given in Schulz (2008) in that it makes the dependence on the laws of nature explicit. We adopt from Schulz (2007) the idea of representing the laws of nature by a non-empty set of possible worlds U: the set U comprises all and only those worlds that conform to the prevailing laws of nature (cf. Schulz, 2007, Sect. 5.6.3.1, p. 140).

Definition 13 *(Possibilities)* Given the set U of law-like worlds, a *possibility* is a pair $\langle v, t\rangle$ where $v \in V$ is a world-fragment and $t \in T$ is a time such that

(i) $U\restriction_t(v) := \{u \in U \mid u\restriction_t = v\restriction_t\} \neq \emptyset$;
(ii) for all $t' \in T$ such that $t' > t$ and for all $Q \in \mathit{Prop}$:

- if $u(t')(Q) = 1$ for all $u \in U\restriction_t(v)$, then $v(t')(Q) = 1$;
- if $u(t')(Q) = 0$ for all $u \in U\restriction_t(v)$, then $v(t')(Q) = 0$;
- otherwise $v(t')(Q)$ is undefined.

We denote the set of all possibilities by $\mathit{Poss}(U)$.

The set U constrains the range of possibilities in two ways: first, the past segment of a possibility must be compatible with the laws of nature, i.e., it must coincide with the initial segment of at least one law-like world. Note that this also ensures that the interpretation is complete with respect to the past: any past time is assigned a state, rather than a proper situation. Second, the future segment of a possibility must be necessitated by the laws of nature in the following sense: a situation is assigned to a future time if and only if that situation holds in all law-like worlds that agree with the possibility in the past. Hence, a possibility will usually not be defined at all future times, and even where it is defined, it will typically not be defined for all propositional variables. These 'gaps' in the future segment reflect the openness of the future.

4.2.2 Predictive conditionals in Schulz (2008)

On Schulz's account, sentences are evaluated at possibilities. Like Kaufmann (2005), Schulz assumes that the morphological present tense expresses non-pastness. The meaning of the tenses is non-deictic and anaphoric (cf. Schulz, 2008, Def. 7, p. 701).

- $[\![\mathsf{PRESENT}_1]\!] = \lambda P \lambda \langle v, t\rangle.\, t_1 \geq t \;\&\; \langle v, t_1\rangle \models P$;
- $[\![\mathsf{PAST}_1]\!] = \lambda P \lambda \langle v, t\rangle.\, t_1 < t \;\&\; \langle v, t_1\rangle \models P$.

Note that since possibilities are defined in the future only for eventualities that are predetermined by the laws of nature, the futurate present tense requires settledness.

The analysis of predictive conditionals proposed in Schulz (2008) closely follows what we have called Kratzer's basic recipe. It assumes as a modal base a set of ontic alternatives and adds an ordering on that set. The set of ontic alternatives of a possibility $\langle v, t\rangle$ comprises all and only those possibilities that represent possible future evolutions of $\langle v, t\rangle$ (cf. Schulz, 2008, Def. 9, p. 703). Having a later temporal center, they are typically defined further into the future.

Definition 14 *(Ontic alternatives)* Given a possibility $\langle v, t\rangle \in Poss(U)$, a possibility $\langle v', t'\rangle \in Poss(U)$ is called an *ontic alternative* of $\langle v, t\rangle$ iff (i) $t' \geq t$ and (ii) $v' \supseteq v$. We denote the set of ontic alternatives of $\langle v, t\rangle$ by $O_{\langle v,t\rangle}$.

Among the ontic alternatives of a possibility $\langle v, t\rangle$, the ordering prefers those possibilities whose temporal center is closer to t (cf. Schulz, 2008, Def. 10, p. 703).

Definition 15 *(Ordering)* For all ontic alternatives $\langle v_1, t_1\rangle, \langle v_2, t_2\rangle \in O_{\langle v,t\rangle}$, we set $\langle v_1, t_1\rangle \prec \langle v_2, t_2\rangle$ iff $t_1 < t_2$.

When it comes to the analysis of predictive conditionals, as Kratzer (1979), Schulz restricts the set of relevant antecedent possibilities to those ontic alternatives that are minimal in the ordering: a predictive conditional is true at a possibility iff the minimal ontic alternatives that make the tensed antecedent true make the tensed consequent true as well.

Definition 16 *(Conditionals in* Schulz, 2008*)*

$$\begin{aligned}&\langle v, t\rangle \vDash \text{If } [\mathsf{TENSE}]A, \text{ then } [\mathsf{NEC}][\mathsf{TENSE}]C\\ &\qquad\qquad \text{iff}\\ &\text{for all } \langle v', t'\rangle \in \mathsf{Poss}_{O,\preceq}(\langle v, t\rangle, [\mathsf{TENSE}]A), \text{ we have } \langle v', t'\rangle \vDash [\mathsf{TENSE}]C\end{aligned}$$

where $\mathsf{Poss}_{O,\preceq}(\langle v, t\rangle, [\mathsf{TENSE}]A) = \{\langle v', t'\rangle \mid \langle v', t'\rangle \in O_{\langle v,t\rangle}$ and $\langle v', t'\rangle \vDash [\mathsf{TENSE}]A$ and there is no possibility $\langle v_0, t_0\rangle \in O_{\langle v,t\rangle}$ such that $\langle v_0, t_0\rangle \prec \langle v', t'\rangle$ and $\langle v_0, t_0\rangle \vDash [\mathsf{TENSE}]A\}$.

Because proper ontic alternatives have a later temporal center, the antecedent and the consequent may be evaluated in the future of the evaluation/speech time. This enables an account of shifted readings. To foreshadow our discussion in Sect. 4.3, note that there may be more than one minimal possibility that makes the tensed antecedent true. Due to the way the ordering is defined, all these antecedent possibilities must share the same temporal center. As we shall see, this leads to problematic predictions.

4.2.3 Schulz (2008) in branching time

In this section, we reconstruct Schulz's account in the framework of branching time. We will see that, whereas Kaufmann's account translates into an Ockhamist semantics, Schulz's account translates into a Peircean one.

To move from Schulzian possibilities to the theory of branching time, we employ $T \times W$ models as an intermediate step. Recall that in defining a possibility $\langle v, t\rangle$, we made use of the set $U\restriction_t(v)$ of all law-like worlds that coincide with v up to the time t. This set straightforwardly gives rise to a $T \times W$ model (that fulfills the additional conditions (iv.c) and (iv.d) following Definition 5): we can naturally define a historical accessibility relation $\approx$ on $U\restriction_t(v)$ simply by relating, at each time, all those possible worlds that share the same initial segment up to that time (i.e., we set $u_1 \approx_{t'} u_2$ iff $u_1\restriction_{t'} = u_2\restriction_{t'}$ for all $u_1, u_2 \in U\restriction_t(v)$ and $t' \in T$).

In the resulting $T \times W$ model, we find not only the possibility $\langle v, t \rangle$ but all of its ontic alternatives as well: while the possibility $\langle v, t \rangle$ corresponds to the set of possible worlds that are $\approx$-related at t, each set of possible worlds that are $\approx$-related at a time $t' > t$ corresponds to a proper ontic alternative $\langle v', t' \rangle$ of $\langle v, t \rangle$. In order to see this, consider some such set of $\approx$-related worlds. By definition, all these worlds have the same past but depict alternative possible futures. Their common past constitutes the past segment of the possibility, whereas the future segment is defined only for eventualities that hold throughout all $\approx$-possible futures.

Now, if we transform the $T \times W$ model on $U\restriction_t (v)$ into a branching time model, following the construction sketched in Sect. 4.1.3, sets of $\approx$-related worlds—and hence, in particular, the possibility $\langle v, t \rangle$ and its ontic alternatives—are mapped onto moments, and possible worlds turn into histories. Since under this transformation, sets of possible worlds that are $\approx$-related at later times are associated with later moments, in the emerging branching time model, the set of proper ontic alternatives of $\langle v, t \rangle$ simply amounts to the set of future moments. Schulz's ordering $\prec$ between ontic alternatives is a generalization $\lhd^*$ of the branching time ordering $\lhd$ among the respective future moments: moments corresponding to two distinct sets of $\approx$-related worlds may be $\lhd^*$-comparable even though they are not $\lhd$-comparable, as the relation $\lhd^*$ depends only on the time parameter.

Schulz's (2008) account of the tenses readily translates into a Peircean branching time semantics, where sentences are evaluated at moments and future truth requires settledness. Recall that on Schulz's account, a futurate present tense sentence can only be true at a possibility if the possibility is defined for the respective eventuality, i.e. if the eventuality is necessitated by the laws of nature given the past course of events. In the corresponding branching time model, this is tantamount to demanding that the future eventuality be true in all histories passing through the respective moment (on the proviso in footnote 15), which is exactly the Peircean interpretation of the future operator. The Schulzian tenses then receive the following translations:

- $\mathsf{PRESENT}Q := Q \vee \mathsf{F_p}Q$;
- $\mathsf{PAST}Q := \mathsf{P_p}Q$.

The crucial difference with Schulz's account consists in the fact that in a branching time model, the Schulzian possibilities are unfolded, by filling in the gaps in all possible law-like ways. Settledness is directly encoded in the semantics of the present tense, whereas on Schulz's account it is built into the notion of a possibility. In both cases, however, future truth is settled truth.

Let us finally turn to Schulz's (2008) analysis of predictive conditionals, which makes essential use of an ordering $\prec$ between ontic alternatives. As noted, in a branching time model, this ordering amounts to a temporal preference ordering $\lhd^*$ on the set of future moments. Schulz's account can then be reconstructed as follows in a Peircean branching time semantics: a conditional is true at a moment iff the earliest future moments that make the tensed antecedent true make the tensed consequent true as well.

Definition 17 *(Schulz's, 2008 conditionals in branching time)*

$$\begin{aligned}\mathfrak{M}, m \vDash\ & \text{If } [\text{TENSE}]A, \text{ then } [\text{NEC}][\text{TENSE}]C \\ & \text{iff} \\ \text{for all } m' \in \text{Poss}_{\trianglelefteq}(m, [\text{TENSE}]A), & \text{ we have } \mathfrak{M}, m' \vDash [\text{TENSE}]C\end{aligned}$$

where $\text{Poss}_{\trianglelefteq}(m, [\text{TENSE}]A) = \{m' \mid m' \trianglerighteq m$ and $\mathfrak{M}, m' \vDash [\text{TENSE}]A$ and there is no moment $m_0 \in M$ such that $m_0 \triangleleft^* m'$ and $\mathfrak{M}, m_0 \vDash [\text{TENSE}]A\}$.

4.3 Evaluating Kaufmann (2005) and Schulz (2008)

As we have seen, Kaufmann's (2005) and Schulz's (2008) accounts of predictive conditionals crucially make use of different formal frameworks. Still, both of them can be reconstructed in the theory of branching time, and while the two accounts look very different at first glance and translate into the Peircean and the Ockhamist semantics, respectively, their reconstruction highlights that they have one central idea in common: on both accounts, the tensed antecedent of a predictive conditional may be evaluated at a future moment, and Kratzer's basic recipe applies. That is, the consequent may be evaluated in the future as well, which is the key to their accounts of shifted readings, as we shall see.

In this section, we assess the accounts put forward in Kaufmann (2005) and Schulz (2008) on the basis of our four questions outlined in Sect. 2, repeated below for convenience.

(i) Why is future reference with the present tense in isolated sentences only possible if the eventuality talked about is settled (i.e. planned, scheduled, or predetermined)?
(ii) Why is this constraint obviated when the present tense occurs in the antecedent of an indicative conditional?
(iii) How does it come about that the consequent tense can get a shifted interpretation in conditionals with present tense antecedents?
(iv) Why are such shifted readings impossible with past tense antecedents?

Question (i). Both Schulz and Kaufmann take the present tense to express non-pastness, and both correctly predict that an isolated present tense sentence with future-orientation requires that the eventuality talked about is settled at the evaluation/speech time.

On Kaufmann's account, the requirement of settledness is a consequence of the idea that every non-modalized tensed sentence contains a covert necessity operator, which—on its ontic construal—expresses settledness. Accordingly, in our reconstruction, the tenses always occur in the scope of the Ockhamist settledness operator $\Box_{\mathsf{o}}$.

For Schulz, the settledness requirement is due to the fact that sentences are evaluated at possibilities $\langle v, t\rangle$, which are defined at future times $t' > t$ only if the respective situation is predetermined by the laws of nature. Accordingly, in our reconstruction, the Schulzian present tense contains the Peircean future operator F_{p}.

Question (ii). Both Schulz and Kaufmann rightly predict that the settledness requirement of the futurate present tense is obviated in conditional antecedents. The reason for this is the same on both accounts, which comes out very clearly in our reconstruction. Even though futurate present tense sentences still require settledness, in conditionals, the present tense antecedent may be evaluated at a future moment, and, obviously, what is settled in the future need not be settled now.

The two accounts only differ in the mechanisms that enable the evaluation at future indices. For Kaufmann, future indices become accessible through the forward extension $\approx^*$ of the historical accessibility relation, which enters with the semantics of 'if'. On Schulz's account, the possible future shift is built into the modal base: the transition from a possibility to one of its proper ontic alternatives goes hand in hand with a forward shift of the temporal center.

It is important to note that on both accounts, the possibility of the forward shift is due to the conditional structure rather than the non-pastness of the present tense. As a consequence, both accounts in principle allow for the possibility of a *double* forward shift with present tense antecedents: the present tense antecedent may be evaluated at a future index, and since the present tense expresses non-pastness, the antecedent event time may lie in the future of that future index. The reason why this does not create any empirical problems is that the present tense allows for simultaneity as well. Still, this may raise conceptual worries, and it leads to empirical problems with past tense antecedents, as we will see shortly.

Question (iii). Both Kaufmann and Schulz can account for shifted readings of conditionals with present tense antecedents. In fact, their accounts are tailored to these cases. As pointed out above, the key of their analyses is that the tensed antecedent of a predictive conditional may be evaluated in the future, and both predict that such a future shift occurs whenever the antecedent fails to be true at the speech time because its truth is not yet settled. Since Kaufmann and Schulz are closely following Kratzer's basic recipe, the tensed consequent is evaluated in the future as well. That is, while the tensed antecedent and the tensed consequent are always evaluated at co-temporal indices, these indices may lie in the future of the evaluation/speech time of the conditional, yielding shifted readings.

To illustrate, consider again Crouch's (1993) example (12), repeated below as (16). Since (presumably) the antecedent *I smile when I get out* is only settled, and hence true, at the end of the interview, the consequent *the interview went well* is evaluated at an index posterior to the interview. Consequently, the past tense in the consequent gets a shifted 'past-in-the-future' interpretation.

(16) [Context: The speaker has an important job interview tomorrow. The addressee will wait for the speaker outside.]

If I smile when I get out, the interview went well.

Note that on neither Kaufmann's nor Schulz's account of predictive conditionals do the relevant antecedent possibilities necessarily comprise all possible future indices at which the tensed antecedent is settled. Rather, they each put constraints on how far into the future the conditional antecedent can take us. Kaufmann filters the set of possible future indices by means of his contextual parameter e. As a result, the relevant

antecedent possibilities can in principle be any future indices in the temporal interval from when the tensed antecedent becomes settled up to the event time itself (where multiple such indices may share the same world). Schulz, on the other hand, employs a minimality criterion. Here, the relevant antecedent possibilities are restricted to the earliest indices at which the tensed antecedent becomes settled. Due to the definition of the minimality ordering involved, all these possibilities need to be co-temporal, i.e., they have the same temporal center. This is problematic, however, as the following scenario illustrates.

(17) [Scenario: John is a linguist working in Tübingen. Thursdays, he sometimes leaves work early to catch the train to Konstanz in order to attend the linguistics colloquium at 3:15 p.m. If possible, he will often come an hour early to hang out with the Konstanz linguists.
There is one train connection per hour, which takes about an hour. John can never leave before 1 p.m. as he teaches in the mornings, and leaving after 2 p.m. would not make sense as he would be too late for the linguistics colloquium.
Finally, John is a busy guy and not very good at planning ahead. So he always decides on short notice whether to catch the next train: at 12:45 p.m., he will consider how far he is with the day's tasks and decide whether to take the train at 1 p.m. In case he doesn't, he will consider again at 1:45 p.m. whether to take the train at 2 p.m. If he doesn't, he will not go to Konstanz that day.
Against this background, a Konstanz linguist says on Wednesday:]

a. If John comes tomorrow, he arrives at 2 p.m.

b. If John comes tomorrow, he arrives at 3 p.m.

Intuitively, both (17a) and (17b) are false, because, at the speech time, both John arriving at 2 p.m. and him arriving at 3 p.m. are open possibilities. However, on Schulz's account, (17a) is wrongly predicted to be true: as a result of her minimality criterion, only the possibility where John decides on short notice to take the train at 1 p.m. is taken into account, as this is the earliest possibility with respect to which it is settled that he is coming to Konstanz that day. Kaufmann's account faces no problem here, of course. All he has to assume is that the contextually supplied restriction e does not filter out the later possibility. This seems sensible, at least in a context where all the facts of the scenario are salient.

To sum up, both Kaufmann and Schulz can account for the possibility of shifted readings with predictive conditionals, and they do so by allowing for a forward shift of the evaluation time of the tensed antecedent. However, their accounts differ as to how the temporal shift is constrained, with Schulz's strategy leading to empirical problems.

Question (iv). Neither Schulz's nor Kaufmann's account can explain why shifted readings are impossible with past tense antecedents. Schulz's account straightforwardly predicts that a conditional, like (18), with a past tense antecedent gets a shifted 'past-in-the-future' reading.

(18) [Context: John has an important job interview tomorrow.]
#If the interview went well, John gets the job / John is happy.

In this example, the event time of the past tense antecedent lies in the future, and, obviously, what is future now will once be past. Hence, while the past tense antecedent fails to be true at the speech time, it may be true at a later time, i.e. at a proper ontic alternative. If at the earliest of those, it is also true that John gets the job or that he is happy (both of which could plausibly be the case), on Schulz's account, (18) is predicted to be appropriate and true, even though the interview is yet to take place.

Kaufmann predicts the possibility of shifted readings with past tense antecedents for analogous reasons. His account may seem to be in a slightly better position, since it features the contextual parameter e, which could be used to prevent a future shift in these cases. Note, however, that in order to generally rule out shifted readings with past tense antecedents, the parameter e would have to be sensitive to the tense in the antecedent. Without such a hardly compositional move, Kaufmann cannot explain why shifted readings are never available with past tense antecedents.

This problem for Schulz's and Kaufmann's accounts was in fact anticipated by Crouch (1993, Sect. 1.1.3; 1994, Sect. 3), who observed an analogous issue for conditionals with past tense antecedents and past tense consequents: he briefly considers an analysis that builds the temporal forward shift into the semantics of the conditional, but immediately points out that such an analysis incorrectly predicts possible past-in-the-future readings of the antecedent and the consequent, respectively.

As mentioned in footnote 4, there are certain examples that may make it seem that past tense antecedents can in fact be evaluated in the future, such as example (19), provided by an anonymous reviewer.

(19) Call John's secretary tomorrow evening to find out when he's coming. If he left at five, he will arrive on time.

However, we take it that the futurate interpretation of the past tense in the antecedent is not due to the conditional itself but rather to the preceding discourse context. To see this, note that for the felicity of the conditional in (19) it is crucial that John already left by the time his secretary is contacted. If the discourse context does not take us far enough into the future, the past tense in the antecedent is not licensed, as illustrated in (20).

(20) [Context: It is **Monday**. John will travel on **Wednesday**. His secretary will arrange his itinerary on **Tuesday**.]

Call John's secretary tomorrow evening to find out when he's coming. # If he left at five, he will arrive on time.

It is well known that imperative sentences facilitate such contextual shifts (Asher and Lascarides, 2003; Schwager, 2006, Ch. 3.1.1; Kaufmann, 2012, Ch. 2.2.3), though other modal operators (*must*, *will*) and operators like *then* can do the same. Along with Kaufmann (2012), we assume that what is involved in those cases is a phenomenon of deictic shift akin to modal subordination.

Crucially, the cases of shifted readings we investigate in the present paper function differently: neither the (unrestricted) future reference of the present tense antecedent nor the shifted interpretation of the past tense consequent requires a particular (modal) operator in the preceding discourse context, and neither requires that any such operator,

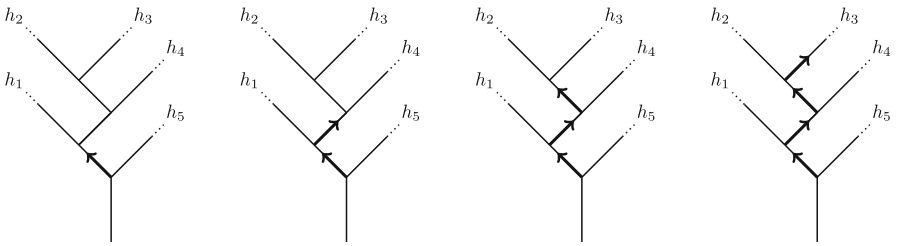


Fig. 4 Four transition sets

if present, shift to a particular time. Examples like (19) thus are instances of a different phenomenon and will be set aside here. With this caveat, the generalization that past tense antecedents never have futurate interpretations is robust and should be explained by a theory of tense and indicative conditionals.

Summary and outlook. Kaufmann's and Schulz's accounts provide sensible answers to the questions (i) and (ii). Both also provide answers to question (iii). However, only Kaufmann's account can make the right predictions here, while Schulz's account ignores 'late' possibilities and hence makes wrong predictions in at least some cases. Both Schulz and Kaufmann lack an answer to question (iv): neither of them can explain why shifted readings are absent in conditionals with past tense antecedents.

We think that this problem, on both accounts, is closely related to the observation we made above when discussing their answers to question (ii): on Kaufmann's and Schulz's accounts, the forward shift of the evaluation time in predictive conditionals is not triggered by the non-pastness of the present tense, but rather by the conditional structure. Accordingly, any tensed antecedent may be evaluated in the future. This makes it unclear how to exclude past-in-the-future readings with past tense antecedents.

The lesson for predictive conditionals that we draw from this is the following: the conditional structure should only 'open up' the future by taking away the settledness requirement, whereas the forward shift of the evaluation time should be due to the futurate present tense. In the following section, we will present an account of predictive conditionals that implements exactly this division of semantic labor.

5 A novel account

In this section, we provide a novel account of predictive conditionals based on the branching time semantics presented in Rumberg (2016), viz. *transition semantics*. As in our discussion of Kaufmann's (2005) and Schulz's (2008) accounts, we proceed in several steps: first, we introduce the general framework, second, we put forth the analysis of predictive conditionals we are proposing, and third, we evaluate our proposal on the basis of the four questions discussed above, highlighting its advantages over Schulz's and Kaufmann's approaches.

5.1 Theoretical background: transition semantics

Rumberg's (2016) transition semantics is a novel approach to the theory of branching time, which generalizes the Peircean and the Ockhamist branching time semantics.[17] On the transition approach, sentences are evaluated not only with respect to a moment as in Peirceanism, nor is truth at a moment relativized to a whole history as in Ockhamism. Instead, the semantic evaluation depends on a moment and a chain of so-called transitions, which can depict any—complete or incomplete—possible course of events, from the past up to an entire history, as illustrated in Fig. 4.

Intuitively, a *transition* is best thought of as a little arrow that specifies a possible direction at a branching point in the tree, i.e., it captures one immediate possible future continuation. Formally, it is defined as a pair $\langle m, H\rangle$, usually written $\langle m \rightarrowtail H\rangle$, that consists of a branching point m and a set of undivided histories $H \subsetneq \mathsf{Hist}(m)$, which continue to overlap for a while after m and branch off only later.[18]

We can naturally construe chains of transitions by defining an ordering that properly aligns them: a transition $\langle m_1 \rightarrowtail H_1\rangle$ is said to *precede* another one $\langle m_2 \rightarrowtail H_2\rangle$ iff $m_1 \lhd m_2$ and $H_2 \subseteq H_1$. Possible courses of events can then be identified with downward closed chains of transitions in that ordering. That is, each linearly ordered set of transitions that is complete towards the past represents a possible course of events. Four examples of such transition sets are provided in Fig. 4. A maximal chain of transitions represents a complete possible course of events and hence corresponds to an entire history. Non-maximal, downward closed chains of transitions, on the other hand, depict incomplete possible courses of events: they allow for alternative possible future continuations and are thus compatible with more than a single history. The set of histories admitted by a given transition set T is given by the intersection $\bigcap_{\langle m \rightarrowtail H\rangle \in T} H$, and it is written $\mathsf{Hist}(T)$.

In transition semantics, sentences are evaluated in a branching time model at pairs m/T consisting of a moment m and a set of transitions T that represents a possible course of events compatible with m, i.e., $\mathsf{Hist}(m) \cap \mathsf{Hist}(T) \neq \emptyset$. As with Peirceanism and Ockhamism, we assume that the valuation of the propositional variables depends only on the moment parameter. Spelling out truth conditions for the past operator is again straightforward: what 'has been the case' is what is true in the actual past. The future operator universally quantifies over all possible futures, as in the Peircean branching time semantics, but now what counts as a possible future also depends on the transition parameter: what 'will be the case' is what is true in every possible future admitted by the given transition set.

(Past) $\mathfrak{M}, m/T \vDash \mathsf{P_t}\varphi$ iff there is some moment m' such that $m' \lhd m$ and $\mathfrak{M}, m'/T \vDash \varphi$;

(Future) $\mathfrak{M}, m/T \vDash \mathsf{F_t}\varphi$ iff for all histories $h \in \mathsf{Hist}(m) \cap \mathsf{Hist}(T)$, there is some moment $m' \in h$ such that $m' \rhd m$ and $\mathfrak{M}, m'/T \vDash \varphi$.

[17] We keep our exposition of transition semantics brief. For a detailed technical overview, we refer the reader to Rumberg (2016). For an introduction that emphasizes the underlying intuitions rather the technical details, see Rumberg (2019).

[18] A branching point is the maximal element in the intersection of two histories. These maxima always exist if any two moments have a greatest common lower bound.

Note that the further the transition set reaches into the future, the fewer histories need to be taken into account when evaluating sentences about the future. Consequently, their truth values at a moment can change under extensions of the given transition set. In particular, a sentence of the form $\mathsf{F}_t Q$, where $Q \in \mathit{Prop}$, can flip from false to true if the transition set is extended towards the future; but once it is true, it will always remain true. This behavior is captured by a new modal operator, which is specific to the transition approach, viz. the so-called stability operator: what 'is stably true' is what remains true no matter how the future evolves further, i.e., no matter how we extend the given transition set. Stability is weaker than settledness but stronger than plain truth: instead of quantifying over all possible courses of events passing through the moment of evaluation, the stability operator quantifies over only those that are extensions of the transition set at hand.

(Stable) $\mathfrak{M}, m/T \vDash \mathsf{S}_t\varphi$ iff for all transition sets T' such that $T' \supseteq T$ and $\mathsf{Hist}(m) \cap \mathsf{Hist}(T') \neq \emptyset$, $\mathfrak{M}, m/T' \vDash \varphi$.

It is important to note that, unlike the Ockhamist history parameter, the transition parameter can be fixed by the context of utterance: the context of utterance fixes the moment of utterance, which in turn uniquely determines the set of transitions that spans the past course of events up to that moment. Given a moment m, we denote the set of transitions in the past of m by $\mathsf{Tr}(m)$; so $\mathsf{Tr}(m) = \{\langle m' \rightarrowtail H' \rangle \mid m' \lhd m \text{ and } \mathsf{Hist}(m) \subseteq H'\}$. That is, the pair $m/\mathsf{Tr}(m)$ is an index initialized in a context of utterance.

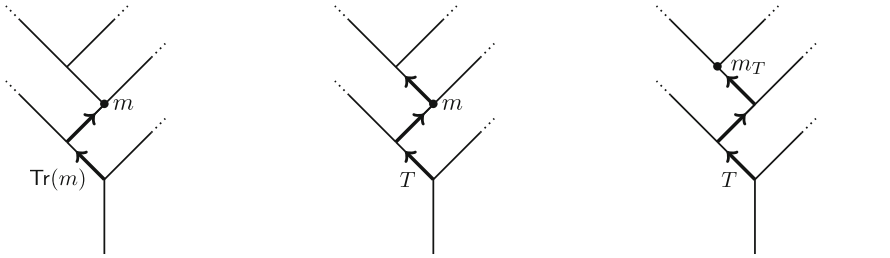
5.2 Predictive conditionals in transition semantics

Before we turn to our account of the temporal interpretation of predictive conditionals, a brief remark on our conception of the tenses is in order. We follow Kaufmann (2005) and Schulz (2008) in assuming that the present tense expresses non-pastness. The meaning of the tenses is given in terms of the temporal operators of transition semantics, yielding the following translations:

- $\mathsf{PRESENT}Q := Q \vee \mathsf{F}_t Q$;
- $\mathsf{PAST}Q := \mathsf{P}_t Q$

The basic idea underlying our analysis of predictive conditionals is this: as illustrated in Fig. 5, we start with the index pair $m/\mathsf{Tr}(m)$ fixed by the context of utterance. That is, the conditional is interpreted at the moment of utterance with respect to the actual past. In a first step, the tensed antecedent is evaluated, and it minimally extends the transition set $\mathsf{Tr}(m)$ towards the future, so far until it is rendered true at m. Let $T \supseteq \mathsf{Tr}(m)$ be one such possible future extension. In a second step, the tensed consequent is evaluated with respect to the extended transition set T, and it is temporally anchored at the earliest moment $m_T \trianglerighteq m$ that is preceded by T, i.e., $\mathsf{Tr}(m_T) = T$. Intuitively, the moment m_T is a first moment of decidedness: from the perspective of m_T, the truth of the tensed antecedent at m is fixed, which is does not hold for any earlier moment.[19]

[19] In order to guarantee the existence of a first moment of decidedness in each case, we need to assume that every branching point has an immediate successor in each possible future, which is obviously always the



(a) Context of utterance: $\mathfrak{M}, m/\mathsf{Tr}(m) \vDash$ If $[\mathsf{TENSE}]A$, then $[\mathsf{NEC}][\mathsf{TENSE}]C$

(b) Antecedent: $\mathfrak{M}, m/T \vDash [\mathsf{TENSE}]A$

(c) Consequent: $\mathfrak{M}, m_T/T \vDash [\mathsf{TENSE}]C$

Fig. 5 Predictive conditionals in transition semantics

According to the analysis of predictive conditionals we are suggesting, a conditional is true at a context of utterance iff in all possible future continuations in which the tensed antecedent is true, once it is decided that it is true, the tensed consequent is true as well. Formally, our proposal can be spelled out as follows:

Definition 18 *(Conditionals in transition semantics)*

$$\mathfrak{M}, m/\mathsf{Tr}(m) \vDash \text{ If } [\mathsf{TENSE}]A, \text{ then } [\mathsf{NEC}][\mathsf{TENSE}]C$$
$$\text{iff}$$
$$\text{for all } m/T \in \mathsf{Poss}_{\subseteq}(m/\mathsf{Tr}(m), [\mathsf{TENSE}]A), \text{ we have } \mathfrak{M}, f(m/T) \vDash [\mathsf{TENSE}]C$$

where $\mathsf{Poss}_{\subseteq}(m/\mathsf{Tr}(m), [\mathsf{TENSE}]A) = \{m/T \mid T \supseteq \mathsf{Tr}(m)$ and $\mathfrak{M}, m/T \vDash [\mathsf{TENSE}]A$ and there is no transition set T' such that $T \supset T' \supseteq \mathsf{Tr}(m)$ and $\mathfrak{M}, m/T' \vDash [\mathsf{TENSE}]A\}$; and $f(m/T) = m_T/T$ where m_T denotes the $\lhd$-minimal moment in the set $\{m' \mid m' \trianglerighteq m$ and $\mathsf{Tr}(m') = T\}$.

On this account, the covert necessity operator in the consequent is interpreted as the stability operator $\mathsf{S_t}$ of transition semantics: the modal base consists of the alternative possible future extensions of the transition set $\mathsf{Tr}(m)$. These represent the possibilities open at the moment of utterance m, and they are naturally ordered by set inclusion $\subseteq$. As on the standard Kratzer analysis, the tensed antecedent functions as a restrictor on this set: it specifies with respect to which of those transition sets the tensed consequent is to be evaluated. The relevant possibilities are the $\subseteq$-minimal possible future extensions $T \supseteq \mathsf{Tr}(m)$ relative to which the antecedent is true at m. The tensed antecedent not only singles out the relevant transition sets, however, but it also determines at which moments the tensed consequent is to be evaluated. Here our analysis departs from Kratzer's basic recipe: the relevant moments need not be the same as the moment at which the tensed antecedent is true. Rather, they functionally depend on the transition

Footnote 19 continued
case if the underlying branching time structure is discrete. Moreover, we need to restrict our considerations to transition sets that contain a last transition and hence lead up to such a moment. This restriction seems quite natural given the local nature of the transition approach: transition sets that lack a maximal element can never be reached from a local standpoint in time.

sets that are provided by the tensed antecedent, and they may lie in the future of m. For any minimal possible future extension $T \supseteq \mathsf{Tr}(m)$, the respective moment m_T is the first moment of decidedness. Consequently, while the antecedent indices m/T are always co-temporal with the moment of utterance m, they need not be co-temporal with the consequent indices m_T/T. The latter may be later indices, giving rise to shifted readings, as we will see shortly.

5.3 Answering the four questions

Let us now consider the answers that our account provides to our initial four questions, repeated once again below:

(i) Why is future reference with the present tense in isolated sentences only possible if the eventuality talked about is settled (i.e. planned, scheduled, or predetermined)?
(ii) Why is this constraint obviated when the present tense occurs in the antecedent of an indicative conditional?
(iii) How does it come about that the consequent tense can get a shifted interpretation in conditionals with present tense antecedents?
(iv) Why are such shifted readings impossible with past tense antecedents?

Question (i). Our account straightforwardly predicts that future reference with the present tense in isolated sentences requires settledness. The reason for this is twofold.

First, on our account—as on Kaufmann's and Schulz's—the present tense expresses non-pastness, which is now captured by the fact that its formal rendering contains the future operator $\mathsf{F_t}$ of transition semantics. Second, in the transition framework, isolated sentences are always evaluated at the pair $m/\mathsf{Tr}(m)$ fixed by the context, where m is the moment of utterance and $\mathsf{Tr}(m)$ the set of transitions that spans the actual past course of events up to m.

In order to see how these two ingredients interact, recall the semantics of the future operator $\mathsf{F_t}$: this operator universally quantifies over the histories passing through the moment of evaluation, but requires a future witness in only those that are admitted by the given transition set. Now, in the case of $m/\mathsf{Tr}(m)$, the restriction imposed by the transition parameter is vacuous: the transition set $\mathsf{Tr}(m)$ does not exclude any of the histories containing the moment m. Hence, when evaluated at $m/\mathsf{Tr}(m)$, the future operator $\mathsf{F_t}$ expresses settledness, as all histories passing through the moment of utterance m need to be taken into account.

It is important to note that on our account—unlike on Kaufmann's and Schulz's—present tense sentences with future-orientation do not generally require settledness, but do so only when evaluated at $m/\mathsf{Tr}(m)$. That is, the settledness requirement results from a combination of the meaning of the future operator $\mathsf{F_t}$ and a particular setting of the parameters of truth.

Question (ii). As Kaufmann and Schulz, we correctly predict that the settledness requirement of the futurate present tense is obviated in conditional antecedents. The prediction is derived on different grounds, however.

Recall that on Kaufmann's and Schulz's proposals, where settledness is taken to be part of the meaning of future-oriented present tense sentences, the obviation of the settledness requirement in conditionals is accounted for by allowing the tensed antecedent to be evaluated at a future moment. The possible forward shift is built into the semantics of the conditional structure.

In our analysis, by contrast, the conditional structure never shifts the evaluation time of the antecedent. Instead, it removes the settledness requirement by allowing the transition parameter to be extended towards the future: the covert necessity operator in the consequent is interpreted as the stability operator $\mathsf{S_t}$ of transition semantics. As such, it universally quantifies over the possible future extensions of a given transition set, while keeping the moment parameter fixed.

Concretely, since the conditional as a whole is evaluated at the contextually supplied pair $m/\mathsf{Tr}(m)$, the tensed antecedent functions as a restrictor on the possible future continuations of m. That is, the tensed antecedent is evaluated at the moment m with respect to the possible future extensions $T \supseteq \mathsf{Tr}(m)$. And crucially, a present tense antecedent with future-orientation can be true at the moment m with respect to such a possible future extension T without being settled at m: by extending the transition set $\mathsf{Tr}(m)$ towards the future, we limit the range of histories that we need to take into account when evaluating the future operator $\mathsf{F_t}$ in the antecedent.

Thus, in our proposal, the conditional structure 'opens up' the future by taking away the settledness requirement of the futurate present tense, without requiring a future shift of the evaluation time of the antecedent. This is possible by exploiting the resources of the transition framework, which makes use of two local parameters of truth: whether the future operator $\mathsf{F_t}$ requires settledness at m depends on the value of the transition parameter. Settledness is required with the transition set $\mathsf{Tr}(m)$, but this requirement can be removed by hypothetically extending the transition set towards the future.

Question (iii). Our analysis—like Kaufmann's and Schulz's—accounts for shifted readings of conditionals with present tense antecedents. But the underlying mechanism is a different one.

On Kaufmann's and Schulz's accounts, shifted readings are possible because the evaluation time of the tensed antecedent may lie in the future, and in this case—following Kratzer's basic recipe—the tensed consequent will be evaluated in the future as well.

On our account of shifted readings, it is only the tensed consequent that is evaluated in the future, whereas the tensed antecedent is always evaluated at the moment of utterance. The evaluation time of the consequent is shifted whenever the tensed antecedent is not yet settled and hence fails to be true at the moment of utterance m with respect to the actual past course of events $\mathsf{Tr}(m)$. In this case, the tensed antecedent will only be true at m with respect to proper future extensions of $\mathsf{Tr}(m)$, and for each minimal extension $T \supsetneq \mathsf{Tr}(m)$ that makes the tensed antecedent true at m, the consequent is evaluated at the respective moment of decidedness m_T.[20]

[20] With this, our account implements the analytical intuition by Cleo Condoravdi (p.c., see also Condoravdi and Lauer, 2015) that 'the antecedent sets the evaluation time of the consequent' in a much more direct way than Kaufmann's and Schulz's accounts.

Returning to Crouch's (1993) example (12), repeated below as (21): the antecedent *I smile when I get out* can only be true at the moment of utterance m with respect to possible future extensions $T \supsetneq \mathsf{Tr}(m)$ that comprise the interview as a whole, and hence the relevant moments m_T are posterior to the interview, licensing the past tense in the consequent *the interview went well*.

(21) [Context: The speaker has an important job interview tomorrow. The addressee will wait for the speaker outside.]

If I smile when I get out, the interview went well.

It is important to note that even though our analysis incorporates a minimality requirement—both for the transition sets $T \supseteq \mathsf{Tr}(m)$ and for the moments m_T—it does not run into the problem we identified for Schulz's account in Sect. 4.3, posed by the example (17), repeated below as (22).

(22) [Scenario: As in (17).]

a. If John comes tomorrow, he arrives at 2 p.m.

b. If John comes tomorrow, he arrives at 3 p.m.

Our account correctly predicts that neither of these conditionals is true. In the given scenario, there is more than one minimal transition set that makes the tensed antecedent true: the possible future in which John takes the later train is not an extension of the possible future in which he takes the earlier train, and the corresponding moments of decidedness are located at different times. Since both transition sets need to be taken into account when evaluating (22a) and (22b), both conditionals come out false.

Question (iv). Unlike Kaufmann's and Schulz's accounts, our account correctly predicts that shifted readings are impossible with past tense antecedents.

Recall that on Kaufmann's and Schulz's accounts, the possible forward shift of the evaluation time is triggered by the conditional structure rather than by the tense in the antecedent. On both accounts, the conditional structure allows the tensed antecedent to be evaluated in the future of the evaluation/speech time, and the tensed consequent is then evaluated in the future as well.

On our account, by contrast, it is only the tensed consequent that may be evaluated in the future, and the possible forward shift of its evaluation time is triggered by the tense in the antecedent rather than by the conditional structure. Since the antecedent is always evaluated at the moment of evaluation/utterance, our account avoids the problematic predictions made by Kaufmann's and Schulz's accounts concerning conditionals with past tensed antecedents: past-in-the-future readings of the antecedent as in (18), repeated below as (23), are ruled out from the start.

(23) [John has an important job interview tomorrow.]

#If the interview went well, John gets the job/John is happy.

Our account also correctly predicts that in conditionals with past tense antecedents, there are no past-in-the-future readings of the consequent either: the tensed consequent is always evaluated with respect to the evaluation/speech time. The evaluation time of the consequent is only shifted if the tensed antecedent fails to be true at the contextually

supplied index pair $m/\mathsf{Tr}(m)$ but is true at m with respect to a proper future extension of $\mathsf{Tr}(m)$. But with a past tense antecedent this can never be: a past tense antecedent that fails to be true at m with respect to the actual past course of events $\mathsf{Tr}(m)$ can never be true at m with respect to a proper extension of $\mathsf{Tr}(m)$. That is, the minimal future extension $T \supseteq \mathsf{Tr}(m)$ that makes the past tense antecedent true will always be $\mathsf{Tr}(m)$ itself. But $m_{\mathsf{Tr}(m)} = m$, and so the tensed consequent will always be evaluated at the moment of utterance m, just as the antecedent. In other words, on our account, the conditional structure 'opens up' the future by allowing the transition set to be extended, but—unlike a futurate present tense—a past tense in the antecedent does not take up this offer.

Summary Like Kaufmann's and Schulz's accounts, our account of the temporal interpretation of predictive conditionals provides sensible answers to questions (i) to (iii), and unlike Kaufmann's and Schulz's accounts, it also provides an answer to question (iv). As suggested above, the latter requires the following division of semantic labor: while the conditional structure should 'open up' the future by removing the settledness requirement, the possible forward shift of the evaluation time in conditionals with present tense antecedents should be due to the non-pastness of the present tense—ruling out shifted readings of conditionals with past tense antecedents. Our account implements exactly this division of semantic labor by exploiting the resources of the transition framework, which makes use of two local parameters of truth: the conditional structure 'opens up' the future by allowing the transition parameter to be extended towards the future, whereas the possible forward shift of the moment of evaluation is triggered by the non-pastness of the present tense in the antecedent. Thus, in our analysis, 'opening up' the future and shifting the evaluation time are two distinct effects, triggered by the conditional structure and the tenses, respectively.

6 Some open questions

6.1 But what about German?

Like the English present tense, the German present tense allows for future-oriented uses. However, unlike in English, in German the present tense does not impose any condition pertaining to planning, scheduling, or predetermination: (24) is an unexceptional thing to say and receives an interpretation corresponding to the English future *will*.

(24) Die Red Sox gewinnen morgen gegen die Yankees.
the Red Sox win tomorrow against the Yankees
'The Red Sox will beat the Yankees tomorrow.'

Our future operator $\mathsf{F_t}$ always comes with a settledness requirement when evaluated at an index $m/\mathsf{Tr}(m)$ supplied by an utterance context. This raises the question how the German present tense, as well as the English future *will*, which both lack a settledness requirement, should be formalized. One promising option would be to assume

that the English future *will* and the German present tense 'open up' the future by hypothetically extending the given transition set $\mathsf{Tr}(m)$, taking away the settledness requirement that accompanies the English present tense. If the relevant transition sets pick out the 'normal' possible futures, such an account would bear a certain similarity to Kaufmann's (2005) approach, where *will* is taken to be restricted by a stereotypical ordering source.

6.2 How far should the shift take us?

Our account and Schulz's differ from Kaufmann's in that the consequent is always evaluated at the respective earliest moments at which the truth of the antecedent is settled. That this yields correct predictions in at least some cases is illustrated by examples like (25) from Kaufmann (2005):

(25) [Let's wait for today's decision regarding his travel arrangements.] Then, if he arrives tomorrow, we'll book his room.

Kaufmann allows the shift to take us further into the future, up to the antecedent event time, depending on the value of his contextual parameter e. At present, it is not clear to us whether this more permissible option is preferable.

6.3 What about epistemic/doxastic readings ?

We have only given an account of the ontic reading of conditionals. However, it is generally agreed that bare conditionals have additional readings, in particular, epistemic or doxastic ones. The most widespread formalization of epistemic/doxastic possibilities equates them with (centered) possible worlds. In the context of branching time, a natural conceptualization of epistemic/doxastic possibilities are *centered trees*, i.e. pairs consisting of a branching time model and a moment in that tree. Epistemic states would then be sets of such trees, i.e. *forests*, and epistemic conditionals should be interpreted on those. The details of such an analysis, of course, remain to be worked out.

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