Many-worlds conditionals

Kilu von Prince
kilu.von.prince@hu-berlin.de

June 26, 2015

Contents

1 Introduction

> *What is being explained is not the rules governing the use of an English word, but the structure of a concept.* (Stalnaker, 1968: 108)

The formalisms used in the field of formal semantics have first been developed in the context of philosophical logic. In many ways, they have been powerful tools for analyzing natural language, but I believe that their original purpose and underlying assumptions ultimately limit their potential for explicating linguistic expressions. Propositional logic was developed as a way to derive the validity of arguments by virtue of certain connectives, regardless of a proposition's specific content – not to understand the meaning of sentences; intensional logic was developed as a way to differentiate between the Fregean notions of *Sinn* and *Bedeutung*, not as a way to understand expressions such as *can* or *must*; the branching-times model was developed as a way to explicate the notion of historical necessity, not to understand the difference between, say, English simple past and *will*. I think that the paradoxes and mysteries surrounding the meaning of conditional clauses and other modal expressions in particular are, to some extent, a result of a mismatch between the original design of the formalisms and the actual workings of natural language.

In this paper, I will show that by giving up the assumption that the truth of all conditional clauses can be settled by empirical observations in the actual world, we can arrive at a radically simpler meaning of the corresponding natural language expressions.

This approach combines several established and familiar features of recent work on the topic. The analysis of indicative clauses with a past reference is very close to Kratzer (1991), and there is a combination of modal and temporal meanings in a branching-times structure, whose spirit is closest to Condoravdi (2002). On the other hand, some of its premises are such a radical departure from the tradition of modal logic that they sound almost like oxymorons: I assume a branching-times structure without historical necessity; and a non-intensional modal type system. Furthermore,

there is no place for an accessibility relation, for modal bases or ordering sources. Similarity between worlds does play a role, but a relatively minor one compared to the Lewis-Kratzer tradition.

2 The formal basis

2.1 A many-worlds framework

In this section, I will introduce an adapted version of the Branching-Times model. This model was probably first conceived of by Prior (1967) and further explored and developed by McArthur (1974); Dowty (1979); Thomason & Gupta (1980); Kamp & Reyle (1983); Thomason (1984); Sabbadin & Zanardo (2003); Belnap (2012) and others. Since then, it has been widely adopted in modal logic and semantics, for example by Dowty (1977); Tedeschi (1981); Abusch (1997); Condoravdi (2002); Kaufmann (2005); Condoravdi & Kaufmann (2005); Werner (2006); Placek & Müller (2007); Fernando (2008); Copley (2009); Arregui (2010); Laca (2012).

The crucial difference to previous approaches is that, in the account proposed here, alternative developments do not cease to matter as time moves on. I will give a brief formal definition, before I discuss the implications of this difference below.

I assume a many-sorted logic, in which the domain of *indices* or world-time pairs D_s has the same status as the domains of individuals D_e and truth values D_t, which I will discuss in more detail in section 2.2.

While D_e and D_t are unordered sets, there is a partial order on the set D_s that is defined by the frame $\mathfrak{U}$:

Definition 1 *A many-worlds frame $\mathfrak{U}$ is a pair $\langle I, < \rangle$, where*

1. *I is a non-empty set of indices i;*
2. *$<$ is an ordering on I such that if $i_1 < i$ and $i_2 < i$, then either $i_1 = i_2$, or $i_1 < i_2$, or $i_2 < i_1$.*

*An index i_1 is called a **predecessor** of i_2 iff $i_1 < i_2$; it is a **successor** of i_2 iff $i_2 < i_1$*

This ordering relation creates a tree structure as shown in figure 1.

One crucial notion for the purposes of this paper is the unit of *histories*:

Definition 2 *A **history** h is a maximal linear subset of $\mathfrak{U}$, such that any two histories have a greatest common lower bound in $\mathfrak{U}$.*

I also assume that indices from different histories can be sorted into groups of indices

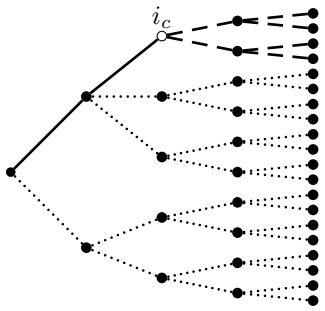

Figure 1: The three domains of the factual (solid line), the counterfactual (dotted lines) and the possible futures (dashed lines). Vertically aligned indices are taken to be simultaneous.

that qualify as simultaneous and that for any given pair of indices, it is possible to specify a temporal order such that one is earlier and the other later.

Definition 3 *Every index i has a time value $t(i)$. There is a strict linear order on time values, such that for every pair $t(i), t(i')$ either $t(i) = t(i')$ or $t(i) < t(i')$ or $t(i') < t(i)$.*

The definition in 1 is identical to the relation between branching times as developed by Thomason (1984). The original purpose of the branching-times model was to account for the notion of historical necessity: What is true in the past is necessarily true in the past – because we cannot alter anymore what has happened. There is therefore a fundamental asymmetry between the future on the one hand and the past and present on the other hand. The future is open, several different developments seem equally possible. The past and present, however, are settled, it is not possible to change what has happened so far. According to the original proposal, this asymmetry involves a specific understanding of necessity. Thomason (1984: 139) asserts that whatever is actually true in the past is necessarily true in the past:

(1) $\phi \leftrightarrow \Box\phi$, if ϕ contains no occurrences of F

Note, however, that the necessity operator $\Box$ is here supposed to have a comparatively weak meaning: $\Box\phi$ is true at a world-time pair $\langle w, t\rangle$[1] iff ϕ is true at every world w' that is identical to w up until the moment t.

In this sense, the framework I propose here could not be further from the original notion of branching times. I assume that there is a difference between actuality and necessity. Just because something actually happened, that does not mean it necessarily happened. What was possible in the past does not cease to be a physical or metaphysical alternative to the actual past and present. What is actually true is not true by necessity. The branching-times system I propose here corresponds to the view

[1]Or, in proper branching-times terminology at an index $\langle b, t\rangle$

that everything that is possible really happens – just not necessarily in the version of reality you experience. Outside of linguistics, this view is explored for example in the many-worlds interpretation of quantum mechanics and other kinds of theories about parallel worlds (compare Tegmark, 2014). I will therefore refer to the proposed framework as a *many-worlds* framework to keep it distinct from traditional branching times. This does not imply a particular ontological commitment on my part: I stipulate the existence of parallel worlds as a notion referred to by linguistic expressions, not necessarily as entities outside the realm of the human mind. Also, as we will see below in section 5, the worlds we refer to linguistically probably differ in some ways from the kinds of parallel worlds envisioned by physicists.

One fundamental achievement of the original branching-times framework is retained in the version I propose: There is still a crucial asymmetry between the present and past as opposed to the future. We can single out one individual line of developments that constitutes the actual past and present as we experience them; but it is not possible to single out one individual future and assert that it be *the actual future*. When we talk about the future, we always have to quantify over groups of possible developments. When we talk about the past, by contrast, we can single out the actual past and keep it distinct from the non-actual pasts.

One may suspect that the difference between the proposed system and the original branching-times framework is purely notional, without consequence for the derivation and truth conditions of modal meanings. After all, it was possible all along to talk about past possibilities by shifting the perspective from the present moment to a moment in the past and explore the possible futures of that (past) standpoint, as suggested e. g. by Condoravdi (2002) or Ippolito (2013). However, in the adapted framework I propose here, this shift to the past is only one out of several ways to talk about past possibilities. Instead of shifting one's standpoint to the past and looking forward, it is also possible to simply look backward and quantify over counterfactual and the actual pasts alike – or only over one of those domains. Crucially, seen from the past, there is no difference between what will turn out to be our actual present, and alternative developments. But seen from the present, we can differentiate between the actual past and the non-actual pasts.

In English, the difference between shifting one's standpoint to the past and quantifying over possible futures as seen from that standpoint vs. quantifying over the actual and counterfactual past as seen from the actual present is instantiated by the contrast in (2):

(2) a. *She had to take the train.* (Given a point in the past relative to the present moment, all – relevant – possible futures seen from that point are such that she takes the train.)
b. *She must have taken the train.* (All – relevant – histories, both the actual and

the counterfactual ones contain a past index such that she took the train.)

Furthermore, when we look at the past, we can choose whether to quantify over a) only the actual world, b) only the counterfactual worlds or c) both. The difference is instantiated by the following examples:

(3) a. *She took the train.* (All histories containing the actual present contain a past index such that she took the train.)
b. *She should have taken the train.* (All – relevant – counterfactual histories contain a past index such that she took the train.)
c. *She must have taken the train.* (All – relevant – histories, both the actual and the counterfactual ones contain a past index such that she took the train.)

Contrary to previous approaches to modal semantics, the differences in interpretation between modal auxiliaries such as *must* and *should* are therefore not based on the choice of different modal bases or accessibility relations. As a a matter of fact, the proposed approach does without an accessibility relation and the notion of modal bases and ordering sources. I will elaborate this point briefly in section 2.3. Instead, the differences in interpretation derive from the differences in modal-temporal reference. I explore the workings of modal auxiliaries in more detail in [author retracted] (in prep.).

2.2 A Ty2 semantics that is not equivalent to intensional semantics

While it is still standard to assume a framework in which worlds, indices or similar do not correspond to a type the way truth values and individuals do (compare von Fintel & Heim, 2005), it is also quite common to use lambda abstractions and quantifiers with world or index variables (for example Schulz, 2014).[2] Most authors do not comment on their choice between traditional Intensional Logic and $Ty2$ logic. Since the work of Groenendijk & Stokhof (1982) and Zimmermann (1989), the difference is widely assumed to be purely a matter of notation. However, the two systems are equivalent only given specific assumptions about correspondences between Intensional Logic and $Ty2$. I will now introduce a version of $Ty2$ that makes different assumptions about correspondences to Intensional Logic and that is not equivalent to it. I will refer to it as $Ty2a$.

The basic correspondences between all three systems are detailed in table 1. Out of the four different cases, three are quite uncontroversial: intensional meanings ($^{\wedge}p$)

[2]This notation was probably first used by (Meredith & Prior, 1956), compare Copeland (2006).

IL	$Ty2$	$Ty2a$
$^{\wedge}p$	$\lambda w.p(w)$	$\lambda i.p(i)$
$^{\vee}p$	$p(i_1)$	$\forall h \in R_H.\exists i \in h : p(i)$(or other, depending on the specific TAM marking on p)
$\diamond p$	$\exists w.p(w)$	$\exists h \in R.\exists i \in h : p(i)$
$\Box p$	$\forall w.p(w)$	$\forall h \in R.\exists i \in h : p(i)$

Table 1: Correspondences between basic expressions from IL to $Ty2$ and $Ty2a$, respectively

correspond to a meaning in which a world or index variable is bound by the lambda operator both in $Ty2$ and $Ty2a$. Possibilities ($\diamond p$) correspond to existential quantification over worlds or histories; necessities ($\Box p$) correspond to universal quantification over worlds or histories.

The crux lies with the so-called extensional meanings. The traditional assumption is that an extensional meaning $^{\vee}p$ corresponds to $p(w_1)$ in $Ty2$: p is true in a specific world w_1. This is where $Ty2a$ is fundamentally different from the other two systems. I assume that it is impossible to name and individuate worlds or histories. I believe that there are no natural language expressions of the form $p(w_1/i_1/h_1)$. Argument variables standing in for indices, histories or worlds cannot be replaced by individual expressions. They can only be bound by the lambda operator or quantifiers. In the proposed framework, therefore, $^{\vee}$ corresponds to a variety of expressions, mostly depending on the presence and definition of modal expressions. By default, a simple sentence without a modal auxiliary or similar will have the form $\forall h \in R_H.\exists i \in R_I.i \in h, p(i)$ – there is an index p in all relevant histories of the specified domain such that p is true at i.

So the simple correspondence between constants in IL to different operators binding a world variable in $Ty2$ does not hold for $Ty2a$. Essentially, the difference between a 'modal' statement such as $\diamond p$ or $\Box p$ vs. a 'non-modal' statement p is not that the former include quantifiers while the latter does not. Instead, the difference between a statement such as *she must have taken the train* and *she took the train* lies purely in the temporal-modal domain that is quantified over.

Another important difference to traditional approaches to modal logic is my assumption that only certain expressions come with index arguments – in a nutshell anything that can be marked for TAM categories plus some other temporal and modal expressions. This means it is not the case that for every expression of a natural language, there is one 'intensional meaning' and one 'extensional meaning'. This may seem like another heresy since the entire idea behind intensional semantics was to formalize Frege's ideas about the difference between *Sinn* and *Bedeutung*. And this difference is thought to apply not only to clauses, but also to expressions referring to individuals such as *the morning star*. I do not have, at this point, a full account of how reference to individuals works in my framework. But I do emphatically not

assume that all definite noun phrases have, or can have, index arguments. So, the many-worlds framework developed here does not explicate the Fregean distinction. In this sense, it is a system of non-intensional modal semantics. I believe that the goal of explicating the Fregean distinction is very different from the goal of understanding natural language modal expressions – my approach is designed to do the latter, not the former. Within philosophy, the notion that Frege's puzzle can be solved by quantifying over possible worlds is quite contested (compare **?**).

In the context of this paper, another consequence of these assumptions is even more decisive: Not only is there a basic difference between *open propositions* of type $\langle s, t\rangle$ that have an index argument and *closed propositions* of type t in which the index argument is bound by a quantifier; it is also impossible to simply add another index argument to a closed proposition to make it 'intensional'. Essentially, a clause such as *she took the train* starts out as a function from indices to truth values, of the form $\lambda i.p(i)$. In this form, it can still be included in a conditional clause that operates on this kind of function, as in *if she took the train, she will arrive in time.* Outside of conditional contexts, the index variable i is existentially closed, yielding a meaning of the form $\exists i.p(i)$.[3] The job of certain expressions such as modal auxiliaries is to bind open index arguments. Therefore, there is no *open* version of a clause containing a modal auxiliary as in *she may have taken the train.* This means that their truth is not relative to a specific world or index. Closed propositions are not properties of indices or worlds. They are either true or false, period. Conditionals, too, are always closed – there is no version of a conditional clause that still contains an open index argument. It is therefore not possible to say something like *this conditional sentence is true* ***at*** w_0/i_0.

In effect, these assumptions make the very strong prediction that you cannot simply iterate modalities. Of course, this flies in the face (again!) of traditional modal logic, where part of the game is to see whether, for example, *it is possible that* p entails *it is necessary that it is possible that* p. While I agree that it is possible, in principle, to make such statements, I suggest that their weirdness is caused by something much deeper than a mere collapse of working memory. I will give a brief outline of how I approach these phenomena in section 5.

2.3 Modality without accessibility, semantics without validity

One radical innovation that sets the proposed framework apart from the tradition of modal semantics is the lack of an accessibility relation. This offense is based on an even greater heresy, namely the absence of a notion of validity from the proposed

[3]Existential closure of index variables involves universal quantification over the relevant histories. We will see the details of this process in section 3.5.

formalism.

The accessibility relation is a device to obtain a system of modal logic that is weaker than Lewis' $S5$ (Copeland, 2006). Philosophical logic was developed as a mechanism to test philosophical arguments for their validity. The basis of propositional logic is the identification of *logical constants* that can be abstracted from the rest of an utterance such that the logical relation between these utterances can be derived from the properties of those constants, independent of the specific content of a proposition. The most basic logical constants of propositional logic are the negation $\neg$, the connectives *and* $\wedge$ and *or* $\vee$, and, traditionally, the material implication $\rightarrow$. This system has proven quite successful in the context of certain generic statements such as x *is either* -2 *or* 2.

In the context of statements referring to specific eventualities of the past, to the future, to mere possibilities or hypothetical scenarios, however, these logical constants alone did not do too well. The general response was to stipulate more logical constants in various frameworks of tense logic and modal logic, such as $\diamond$, $\Box$, $\diamond\!\!\rightarrow$, $\mathbf{F}(\phi)$, $\mathbf{P}(\phi)$ and so on. Modal operators such as $\diamond$ and $\Box$ in particular are thought to move to the beginning of a phrase in LF to be interpreted with wide scope. As a result, the relation between temporal and modal expressions on the one hand and the rest of the clause on the other hand, has gotten ever more obscure and less compositionally transparent. For example, the seminal approach by Kratzer (1991) proposes that all indicative conditionals involve a, sometimes covert, *must* operator, while the expression *if* is said to be vacuous. Similarly, TAM expressions are said to merely 'signal the presence of [certain, temporal and modal] operator[s]' (Schulz, 2014: 117) rather than contributing directly, by virtue of their lexical definition and in their *in situ* position, to the meaning of the clause. This practice has become so ingrained in the field of modal semantics that it hardly seems to cause any chagrin to most authors (an exception is Schulz 2010).

The framework I propose here does not have any logical constants at all. Expressions such as *and*, *or*, *if* and TAM expressions are defined as lambda-functions in exactly the same way as all other natural language expressions. It is therefore not a logical system in the sense that it does not allow to establish rules of proof purely based on the presence of certain operators. There is no validity function. This does not mean that, in this framework, we cannot explore logical relations between different utterances. On the contrary, we will see that it makes very precise and powerful predictions about the truth conditions and logical compatibility of natural utterances. But it is not designed to prove validity, be testable for completeness or have other properties typically required of logical systems. And this is why it can do without an accessibility relation.

At the same time, the proposed theory achieves an effect that is similar to the accessibility relation by two different mechanisms: One is the variable of contextual

relevance R that constrains quantification over indices and histories; the other is the branching relation on indices, which allows us to specify whether a proposition should hold in the domain of the actual, the possible, the counterfactual or a combination thereof.

For a detailed account of how this works in the context of modal auxiliaries, see [author retracted] (in prep.).

I will not be able to explore every detail of how the proposed framework compares to the various systems of modal logic that have been discussed in the literature in this paper (or probably in my lifetime). The purpose of this paper is to show that, at least in the context of conditional clauses, we can do very well without an accessibility function.

3 Tense, aspect and modality: some definitions

3.1 Preliminaries

The definitions proposed here suggest that simple English tenses refer directly to certain moments in time relative to a contextually determined moment, which is by default the time of utterance. Another point of reference corresponding to the Reichenbachian *point of reference* is only introduced by the perfect with *have*. It may yet turn out to be necessary to assume a more complex system in the spirit of Reichenbach (1947) and Klein (1994) (also compare Portner, 2011), but for our present purposes, these assumptions should be sufficient.

One basic assumption that I make is that the lexical reference of TAM expressions is often much wider than their interpretation in a specific environment suggests. The interpretation of a TAM expression is not only determined by its lexical definition, but also by the contrast to paradigmatic alternatives and by general pragmatic constraints. The most important pragmatic principle I assume is that one should avoid talking and thinking about indices other than the actual ones. Especially reference to counterfactual developments should be avoided at all cost. This principle may well be a special case of the Gricean relevance requirement: Given the chance, we would always prefer to know what actually happened than what might have happened. By quantifying over counterfactual indices, the speaker in effect requires us to allocate significant resources of our working memory to compute potentially spurious interrelations between propositions that do not have any real bearing on our lives at all. Only a lack of alternatives can justify such an annoying behavior.

Definition 4 *Pragmatic principles for use interpretation of TAM expressions:*

(i) Avoid any reference to counterfactual indices. If you can choose between two ex-

pressions such that they refer to the same actual or future indices, but one includes counterfactual indices and the other does not, always choose the latter if at all possible.

(ii) Always choose the expression with the most narrow reference possible.

(iii) If the reference of an expression includes actual indices, the default is to ignore reference to non-actual (future or counterfactual) indices.

The third principle is in part dependent on the first principle: The default interpretation is only available if principle 4-i is satisfied.

In the theory proposed here, it is these pragmatic principles that account for the old puzzle of the weakness of *must* (see von Fintel & Gillies 2010 and Lassiter 2014 for different recent approaches to the problem): Given that *must* universally quantifies over (both the actual and counterfactual) worlds, should it not result in a stronger assertion than the simple present, which only refers to the actual world? Yet, *Laura must be in her office* appears to involve a weaker commitment than *Laura is in her office.* In my account, this phenomenon is explained by the assumption that any reference to counterfactual worlds comes at a high cognitive cost while its practical value is highly questionable. It is therefore to be avoided at all cost. If you can talk about only the actual world, it is imperative that you do. So by using *must* instead of simple present, the speaker signals that, for some reason, she cannot simply talk about the actual world alone. The default reason for quantifying both over the actual world and counterfactual ones is an inability to distinguish them with respect to the relevant proposition – the speaker does not know what is in fact the case. Hence the evidential or epistemic interpretation.

I will now turn to the definitions of individual TAM expressions of English. For each expression, I will first outline the main observations on which my assumptions about their meanings are based. Formal definitions will be given in definition 7.

3.2 *Will* and *would*

Let us start with *will.* It is quite uncontroversial to assume that *will* refers to possible futures, that is possible continuations of the actual present as in *Laura will arrive tomorrow morning.* It is also well established that *will* can refer to epistemic possibilities in the actual present as in *Laura will be in her office at the moment, I suppose.* What about counterfactual futures, can *will* refer to those? Apparently not: In (4), the apodosis can only refer to the possible futures, and this is not conditioned by the simple past in the protasis as witnessed by sentences such as (5):

(4) If Laura took the train, she will arrive tomorrow

(5) If Laura took the train, she would arrive tomorrow.

We also cannot use *will* to talk about past moments, actual or counterfactual:

(6) *Laura will take the train yesterday.

Cases involving perfect *have* will be treated below. So *will* refers to indices that are simultaneous with the actual present i_c (including i_c itself) and to successors of the actual present. The fact that its reference to future and counterfactual indices is readily available, despite the fact that it also refers to the actual present, would seem to contradict principle 4-iii. However, as we will see below, this pragmatic principle is preempted by the paradigmatic contrast of *will* to the simple present, which is the default way to refer to the actual present. A graphical illustration of the meaning of *will* is given in figure 2.

Continuing with *would*, it seems quite clear that it refers only to counterfactual indices: When I say *I would come to your party ...*, we expect a continuation such as *..., but I can't get a babysitter tonight.* The implicature is that *I will not come to your party*. Note that this is only an implicature. By talking about what will happen in counterfactual futures, we do not exclude the possibility that the same may happen in possible futures, too. We just imply that we do not expect it to happen, otherwise we could simply refer to the possible futures directly.[4] Similarly with conditionals such as (5), the implicature is that we do not expect Laura to take the train. We are just entertaining a hypothetical scenario. Concerning its temporal scope, *would* has the same restrictions as *will*:

(7) Laura would be in Perth now/ tomorrow/ *yesterday.

Of course, there is another use of *would* as habitual past, as in (8):

(8) As children, we would always steal cherries from the neighbors.

I assume that in this case, we are dealing with a genuinely different meaning of *would*. For present purposes, I will focus only on counterfactual *would*. Combinations with perfect *have* will be treated below. So far we have seen that counterfactual *would* refers to counterfactual indices simultaneous with or later than the actual present. This meaning is illustrated in 3.

[4]Pragmatic implicatures of quantifications over counterfactual and possible futures can get quite complicated. A full account is given in [author retracted] (in prep.).

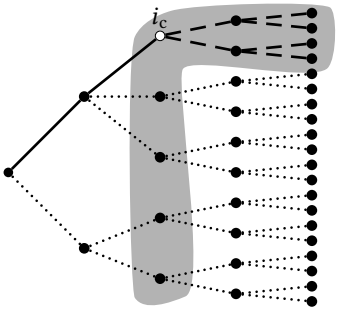

Figure 2: The meaning of English *will*

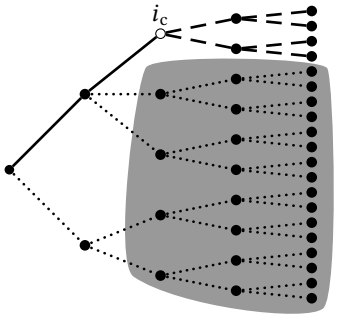

Figure 3: The meaning of English *would*

3.3 Simple past and simple present

The next TAM expression to be treated here is the simple present. We can safely assume that its reference includes the actual present i_c. But its meaning also appears to include the possible futures as suggested by sentences like the following:

(9) If Laura takes the train tomorrow, she'll arrive in Moscow on Monday.

By default, the potential future reference of the simple present tense is ignored, as required by principle 4-iii. In conditional clauses, however, the set of relevant histories is primarily determined by the finite TAM expression in the apodosis, as I will discuss in section 4.1. In (9), the apodosis is headed by *will.* And *will* is interpreted by default to refer to the future, since we could have used the simple present instead if we only wanted to refer to the actual present. Since the apodosis thus forces us to think about possible futures anyway, we might as well also consider the future indices in the scope of the simple present.

Does the simple present include any other temporal-modal domain? What about the past? Colloquially, one may encounter a situation where the speaker uses the simple present to refer to past events:

(10) Last week our neighbors invited us over to a barbecue with their friends. So, I **walk** up to this guy who works in finance and ask him…

But these cases probably involve the shift of the contextually given actual present i_c to the past, since it is not regularly possible to say something like **they meet yesterday.* Does the simple present include counterfactual indices? The fact that it does usually not imply any uncertainty alone does not show conclusively that its reference is restricted to the actual present and possible futures, since other interpretations may be preempted by principle 4-iii. But if it did include counterfactual indices, it should be possible to combine it with *would* in a counterfactual conditional such as in (11):

(11)**If Laura takes the train, she would arrive in time.*[i]

The fact that such sentences are not particularly acceptable indicates that the reference of the simple present does not include counterfactual indices. The simple present, then, refers to the actual present moment and to its possible futures. An illustration is given in figure 5.

The last TAM-element to be examined before we move on to perfective *have* is English simple past. We can safely assume that its reference includes the actual past as in the default interpretation of *Laura took the train.* It can also refer to the counterfactual present and future as witnessed by (12):

(12) If Laura took the train now/ tomorrow, she would arrive in Berlin in time.

It can apparently not refer to the actual present or possible future, as illustrated by the following example:

(13)**If Laura took the train now/ tomorrow, she will arrive in Berlin in time.*

Obviously, the unacceptability of (13) is not due to some general incompatibility between simple past and *will* – as long as the reference of the simple past is to the actual past, the combination with *will* is just fine:

(14) If Laura took the train yesterday, she will arrive in Vladivostok on Monday.

Furthermore, simple past does apparently not refer to the counterfactual past, as seen in (15):

(15)**If Laura took the train yesterday, she would arrive in Vladivostok on Monday.*

To express the corresponding meaning, it is necessary to use the past perfect, to which we will return presently. In sum, the simple past refers to the actual past as well as the counterfactual present and future. An illustration is given in figure 4.

[i] I don't have very good intuitions about this, I think in some cases it might be acceptable to have this kind of conditional. It may again involve a shift of the actual present i_c to a counterfactual index or some other mechanism. At any rate, this is not a canonical way to express a conditional clause, but it may be worth investigating its acceptability.

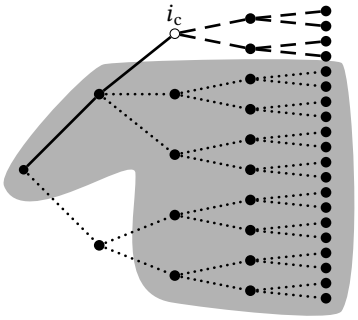

Figure 4: The meaning of English simple past

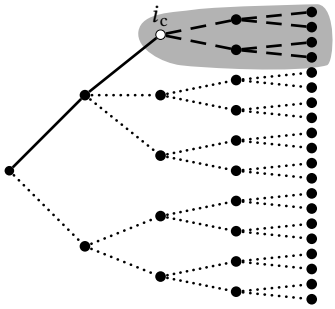

Figure 5: The meaning of English simple present

3.4 Perfect

I assume that the perfect aspect expresses that an event takes place at an index that is a predecessor of one of the indices specified by the tense of the clause. For example, when we combine perfect *have* with simple present, as in *Laura has taken the train*, we still talk only about the actual world, not about counterfactual ones. This means that the perfect aspect does not simply specify that the index of the event be prior to the index of reference; it also has to be on the same history. The formal implementation is given in definition 7 in the following section.

This definition only takes care of the anteriority effect of the perfect. There are other aspects to its meaning that are aspectual in a more literal sense which I will not address here. The only context in which we are going to discuss the perfect aspect here is its application to counterfactual conditionals with a past reference such as the following:

(16) If Laura had taken the train, she would arrive in time.

(17) If Laura had taken the train, she would have arrived in time.

As we have seen in section 3.3, the definition of the simple past does not include past counterfactual indices. In order to refer to those, we therefore need to combine it with the perfect aspect. The derivation of the pluperfect is given in figure 6, an illustration is given in figure 8. Like the simple past, *would* only refers to the counterfactual present and future, not the past. If the apodosis of a conditional also refers to the counterfactual past, as in (17), the auxiliary *would* also needs to combine with perfect *have*. The derivation of the meaning is given in figure 7, an illustration is provided in figure 9.

In principle, the definitions and derived meanings allow for a wider variety of temporal-modal interpretations than the default developed so far. For example, since *would* includes indices from the remote future, *would have* may also refer to indices of the

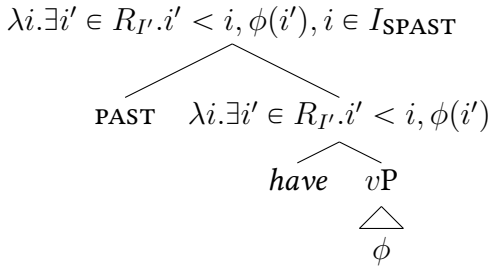

Figure 6: Deriving the pluperfect. For definitions of the simple past and perfect *have*, see definitions 7 and v.

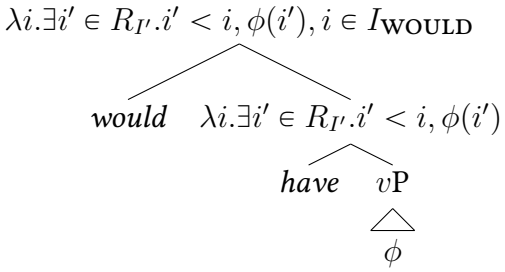

Figure 7: Deriving the meaning of *would have*. For definitions of *would* and perfect *have*, see definitions 7 and v.

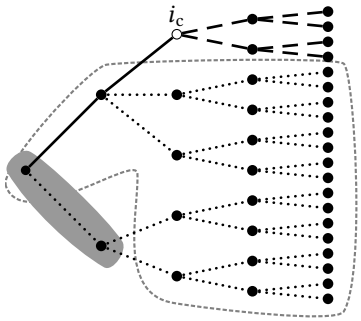

Figure 8: The pluperfect

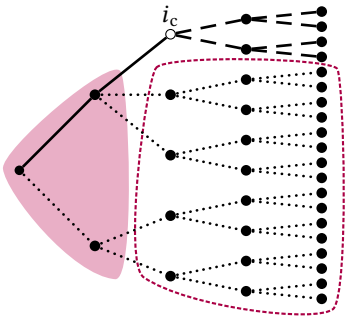

Figure 9: The combination of *would* with perfect aspect

future instead of the past. In some situations, this interpretation is in fact fine, as discussed in Ogihara (2000) – in a context in which John has already given flowers to Mary, the following sentence is fine:

(18) If John had given flowers to Mary TOMORROW$_F$, she would have been pleased.

I will return to these cases for a brief discussion in section **??**. For the moment, it suffices to note that in most contexts, conditionals with the pluperfect in the protasis will be interpreted as referring to the past, because otherwise we would not have to bother with the perfect aspect.

Similarly, since both the pluperfect and *would have* also include actual indices, one might interpret a clause such as (17) as indicative, rather than counterfactual. But then, one could have chosen the form in (19) instead, which is simpler in that it does not include perfect aspect:

(19) If Laura took the train, she arrived in time.

In the preceding discussion, I have appealed to two sets of pragmatic principles: One set is given in definition 4 and has to do with a strong preference to avoid mentioning and thinking about counterfactual indices. The other set has to do with structural complexity: If you can choose between two structures such that one is simpler than the other, do choose the simpler one. A full-fledged account of this latter type of principle would involve exact definitions of structural complexity, which I am not going to develop here. For present purposes, it should suffice to assume that a clause with an aspectual layer of perfect aspect is more complex than one without.

Since the two types of constraints can obviously interact, it is necessary to fix priorities between them: If I can choose between two expressions such that one is simple and includes counterfactual indices and the other one is complex and does not include counterfactual indices – do I prioritize the avoidance of counterfactual references and choose the more complex one or do I prioritize simplicity and choose the simpler one?

In the context of the expressions discussed so far, it seems that simplicity trumps avoidance of counterfactual indices – otherwise, we would expect that the simple past should generally be replaced by present perfect in all actual contexts. Other factors may also be playing a role here, for example, the perfect may come with certain presuppositions that we want to avoid when we use the simple past.

3.5 Existential closure of index arguments

So far, I have derived the temporal-modal reference of various tense and mood markers based on their interpretation in various environments. I will now turn to the quanti-

fiers that bind the index argument of these expressions. While some modal auxiliaries such as *may* and *must* come with lexically built-in quantifiers, the expressions discussed in the preceding sections, including *will* and *would* do not.

In cases where the index argument of a clause is not bound by a lexically introduced quantifier, it undergoes existential closure. And, I assume, existential closure of index arguments involves universal quantification over histories. The process is defined in (20):

Definition 5 *Existential closure of index arguments:*
$\lambda i.\phi(i) \rightarrow \forall h \in R_H.\exists i \in R_I.i \in h, \phi(i)$

In the context of the actual present and past, an existentially closed sentence means that an event took place in all histories that are identical up to the present moment. Consider (20):

(20) Laura took the train.

The past tense marker gives us a reference to the actual past. References to the counterfactual present and future are not in R_H as per 4. After existential closure, (20) is interpreted to mean that all histories that are identical up to the actual present, there is an index i in the relevant period of time such that Laura takes the train at i. In other words, Laura took the train in the actual past.

Turning to the possible future, consider (21):

(21) Laura will take the train.

After existential closure, this sentence means that all histories considered relevant by the speaker contain an index i in the possible future (in the relevant period of time) such that Laura takes the train at i. Given the amount of ink that has been spilled on the future tense (compare McArthur, 1974; Ultan, 1978; Fleischman, 1982; Werner, 2006; Copley, 2009; Broekhuis & Verkuyl, 2013), this brief characterization may seem criminally nonchalant. I do address some of the many puzzles associated with the future reference in [author retracted] (in prep.). However, I should emphasize at this point that, in some ways, the system I propose is intentionally less powerful than many recent accounts of temporal semantics, because I generally believe that language is fundamentally quite simple. The interface with our other cognitive processes and our world knowledge is extremely complex, but the meanings encoded by lexical definitions of morphemes and their structural composition is very straightforward. I suspect that whenever we want to turn to hidden or invisible operators and processes to explain our interpretations of natural language expressions, we are in effect trying to put a component of meaning into language that is in fact located elsewhere

in our cognitive apparatus. In part, the urge to do so nonetheless is a legacy of the philosophical ambition to settle arguments purely based on the information explicitly encoded by language – which I believe is often impossible.

In the case of statements about the future, for example, we can have endless debates about the proper ways to identify which future developments should qualify as relevant in the context of a particular proposition. But we cannot, in a narrow sense, empirically decide about their truth. If I were to utter (21), and my listener and I wait for the relevant period of time and Laura does not turn out to take the train, my listener may well say to me *you were wrong*. Failing to include the one development that will turn out to be your actual reality in your set of relevant futures makes you as wrong as you ever can be about the future. By the same principle, if Laura does turn out to take the train, I may confidently announce that I was right. But in effect, I can never truly empirically test the truth of a prediction about the future because I would have to be able to check each of those developments that I considered relevant at the time of utterance, and the actual line of developments may not even be among them.

The truth of a sentence headed by *would* is even more elusive than a claim about the possible future. Consider (22):

(22) Laura would take the train (if…).

This means that all contextually relevant histories contain a counterfactual index i in the relevant present or future such that Laura takes the train at i. As the brackets suggest, we usually only find such an utterance in a context that provides at least some of the criteria that restrict contextual relevance explicitly. There is no way we can ever truly prove or disprove the truth of such a statement, we may only debate their plausibility. I will return to the truth conditions of counterfactual clauses in more detail in section 4.3.

3.6 Summary

Concluding this section, I will summarize my previous observations about the meaning of English TAM expressions and formalize their definitions. I will then explore briefly how they compare to previous accounts.

To begin with, I will first define a few modal-temporal domains that appear to be basic in the context of English TAM expressions:

Definition 6 *If the index i_c is the contextually given present moment in the actual world, then*

(i) H_c is the set of histories that contain the actual present i_c.

*(ii) the **counterfactual domain** I_{COUNT} is the set containing all indices that are neither predecessors nor successors of i_c.*

*(iii) the domain of the **possible futures** I_{FUT} is the set containing all indices that are successors of i_c.*

Basic observations suggest that *will* refers to the possible futures and do indices that are simultaneous with the actual present; *would* refers to counterfactual indices in the present and past; simple present refers to the actual present and to possible futures – the future reference is blocked in most contexts by the pragmatic requirement in definition 4-iii. The simple past refers to indices in the actual past and to counterfactual indices in the present and future – reference to counterfactual indices is also blocked in most contexts by requirement 4-iii. The perfect aspect asserts that an event takes place at an index that is a predecessor to the index whose temporal-modal reference is specified by the dominating tense marker. These definitions are formalized in definition 7.

Definition 7 *Some TAM expressions of English*

(i) $[\![\textbf{will}]\!] = \lambda P \lambda i.P(i), i \in I_{WILL}$, *where* $I_{WILL} = \{i | i_c < i\} \cup \{i | t(i) = t(i_c)\}$

(ii) $[\![\textbf{would}]\!] = \lambda P \lambda i.P(i), i \in I_{WOULD}$, *where* $I_{WOULD} = \{\{i | t(i_c) < t(i)\} \cup \{i | t(i_c) = t(i)\}\} \cap I_{COUNT}$

(iii) $[\![\textsc{simple present}]\!] = \lambda P \lambda i.P(i), i \in \{i_c \cup I_{FUT}\}$

(iv) $[\![\textsc{simple past}]\!] = \lambda P \lambda i.P(i), i \in I_{SPAST}$, *where* $I_{SPAST} = \{i | i < i_c\} \cup \{\{i | t(i) \geqslant t(i_c)\} \cap I_{COUNT}\}$

(v) $[\![\textsc{perfect}]\!] = \lambda P \lambda i. \exists i'.i' < i, P(i')$

The proposed treatment of the tenses differs quite fundamentally from most previous approaches to the English tenses in that it simply takes their various interpretations at face value. I assume that they directly derive from their lexical definition. The potential of the simple past to express counterfactuality has puzzled researchers for decades and a lot of the recent literature is concerned primarily with this phenomenon (Iatridou, 2000; Arregui, 2009; Ippolito, 2013; Romero, 2014; Schulz, 2014). But in the approach proposed here, there is nothing mysterious about it. The reference to counterfactual worlds is built into its lexical meaning. Nor do we need a special theory to explain why we need the perfect aspect in combination with the simple past (the pluperfect) in order to refer to past counterfactual indices – again, this follows directly from the definitions of the two elements involved.

The meaning of the subjunctive and its relation to the simple past is also rendered trivial by the proposed account: the vestigial English subjunctive in *If I **were** rich, I would buy a house with a garden* refers to the counterfactual present. So does the German subjunctive II as in (23):

(23) Wenn ich reich wäre, würde ich ein großes Haus mit Garten kaufen.
if 1SG rich were would 1SG a big house with garden buy
'If I were rich, I would buy a big house with a garden.'

The German subjunctive I and subjunctives in other languages may work in different ways, though.

Not only the counterfactual meanings of the past and subjunctive are straightforward, so is the simple present. Other authors have often speculated that the present tense be vacuous, only defined by its contrast to the past. This sentiment is summed up by Portner (2003) as follows:

> 'While the absence of the past is, of course, typically called "the present", morphological evidence may be taken as suggesting that the present is mere lack of past;'

In the proposed framework, however, the present tense does encode very specific information: It requires that a statement be true either at the present actual moment (by default), or in the possible future (in conditional and other specific contexts).

In this sense, my assumptions about the semantic contribution of the tenses to the meaning of a sentence are radically simpler than in previous approaches. In this framework, TAM expressions do not merely 'signal the presence of [certain, temporal and modal] operator[s]' as proposed for example by Schulz (2014: 117). There are no layers of covert tenses and no vacuous morphemes. Lexical meanings of TAM expressions can be interpreted in situ without much ado. In the following sections, we will see how these assumptions play out in the context of conditional clauses.

4 Conditionals

4.1 General properties

There are two basic intuitions about the meaning of *if*. They correspond to two different definitions in the proposed framework, but it will turn out that these have identical truth conditions. One intuition has been explored, among others, by von Fintel (1997, 1999, 2001) and von Fintel & Iatridou (2002). In the terms of the proposed framework, this intuition says that *if* takes two sets of histories and asserts that one set of histories is a subset of another set of histories:

Definition 8 *The meaning of* if *(first version):*
$[\![\textbf{\textit{if}}]\!] = \lambda p_{\langle s,t\rangle}\lambda q_{\langle s,t\rangle}.H_p \subseteq H_q$*, where* $H_\phi = \{h | h \in R_H, \exists i \in h.\phi(i)\}$ *– the set of those contextually relevant histories that contain an index for which* ϕ *is true.*

Another intuition is that the antecedent of a conditional clause is a topic. Haiman (1978) was the first to note that conditionals are marked like topics in a number of typologically unrelated languages. Biscuit conditionals such as *if you're hungry, there's biscuits in the pantry* have been fruitfully analyzed as involving a topical *if*-clause – Hinterwimmer *et al.* (2008) argue that the same analysis can also be applied to indicative conditionals more generally. In my approach, a topic-version of *if* has to have a different set-up from the definition in 8. Crucially, it is a function that takes only one argument of type $\langle s,t\rangle$ and one argument of type t rather than two arguments of type $\langle s,t\rangle$. In effect, if the consequent clause does not include a quantifier over indices, its index argument has to undergo existential closure. Furthermore, the topical *if* is an information structural function. I will define it using the conventions of structured propositions, where $\langle \alpha, \beta\rangle$ is an ordered set such that α is the topic and β is the comment of an utterance.

Definition 9 *The meaning of* if *(second version)*
$[\![\textbf{\textit{if}}]\!] = \lambda p_{\langle s,t\rangle}\lambda \mathfrak{q}_t.\langle H_p, \mathfrak{q}\rangle$*, where* $H_\phi = \{h|h \in R_H, \exists i \in h.\phi(i)\}$*. Read: Given/ within the set of relevant histories such that* p *is true, all histories contain an index such that* q *is true.*

The two definitions predict the same truth conditions. Ignoring the specifics of temporal-modal reference for the moment, let us recall that existential closure of an index variable involves universal quantification over relevant histories. This means that for a conditional of the form *if* p *then* q, we get the following two logical forms respectively:

(24) a. $H_p \subseteq H_q$ (definition 8)
b. $\langle H_p, \forall h \in R_H.\exists i \in R_I.q(i)\rangle$ (definition 9)

Both expressions are false if and only if there is a relevant history that contains an index for which p is true, but no index such that q is true. Let us take a moment to appreciate how the truth conditions in this set-up differ from previous approaches to conditionals: One crucial difference is that, generally, our empirical observations of one particular history are not enough to know whether a conditional is true or not. This is a direct contradiction to a basic philosophical assumption that underlies all standard logic. As Stalnaker (1968: 99) puts it:

"…contingent statements must be capable of confirmation by empirical evidence…"

Traditionally, the truth conditions of a conditional clause can be given by a simple truth table, that will tell you, for example, that $p \rightarrow q$ is true if p is true and q is true. In the approach proposed here, by contrast, the conditional is of a different type than

	$H_p \subseteq H_q$	$\langle H_p, \mathfrak{q} \rangle$
$\exists h \in R_H.[\exists i \in R_I.i \in h.p(i)], [\exists i' \in R'_I.q(i')]$	T/F	T/F
$\exists h \in R_H.[\neg\exists i \in R_I.i \in h.p(i)], [\exists i' \in R'_I.q(i')]$	T/F	T/F
$\exists h \in R_H.[\exists i \in R_I.i \in h.p(i)], [\neg\exists i' \in R'_I.q(i')]$	F	F
$\exists h \in R_H.[\neg\exists i \in R_I.i \in h.p(i)], [\neg\exists i' \in R'_I.q(i')]$	T/F	T/F

Table 2: The closest thing to a truth table you can get for many-world conditionals

its composite clauses: we therefore have to indicate for which index p and q are true and whether these indices are part of the same history. As stated above, we may say that a conditional *if* p*, then* q is false if there is a relevant history that contains an index such that p is true but no index such that q is true; but the mere existence of a history such that p is true and q is also true is not enough to ascertain the truth of the conditional. This does not mean that conditionals do not have definite truth values or that we need more than two truth values or that there is anything fuzzy about them. It just means that the truth of conditionals is generally underspecified by empirical observations. An illustration of this point is given in table 2.

While both definitions of *if* above have the same truth conditions, we will see below that definition 9 is more versatile and I will therefore continue to work with this definition. Definition 9 says that the antecedent of a conditional restricts the scope of the consequent. This approach is almost identical to the approach to indicative conditionals by Kratzer (1991). The most striking difference is that I assume the same definition of *if* for both indicative and counterfactual conditionals. It is one of the strengths of my proposal that I need not stipulate a different definition of *if* for these different types of conditionals, nor a covert subjunctive operator or similar. The different truth conditions derive in a straightforward manner from the definitions of *if* and the TAM elements involved.

4.2 Indicatives

4.2.1 Truth conditions

We are now ready to derive the meaning of our first conditional clause. Let us start with a past indicative:

(25) If Laura took the train, she arrived at 2pm.

When we apply the definitions in 7 and 9, we get the following derivation:

(26) $[\![\textbf{if}]\!](\lambda i.\textbf{take.the.train}(l)(i), i \in I_{\text{SPAST}})(\lambda i'.\textbf{arrive}(l)(i'), i' \in I_{\text{SPAST}}, t(i') = 2pm) =$

$\langle\{h|h \in R_H, \exists i \in R_I.i \in h, \textbf{laura take the train}(i), i \in I_{\textsc{spast}}\}, [\forall h' \in R_H.\exists i' \in R'_I.i' \in h', \textbf{laura arrive}(i'), i' \in I_{\textsc{spast}}, t(i') = 2pm]\rangle$[5]

In words: within the set of contextually relevant histories that contain an index i in the domain denoted by the simple past such that Laura takes the train at i, all histories are such that they contain an index i', also in the simple past domain, such that Laura arrives at i' and the temporal value of i' is 2pm.

Both clauses of the conditional sentence are marked for simple past and in accordance with definition 4, we avoid thinking about counterfactual indices. This means that R_H is restricted to those histories that are identical up to the present moment.[ii] There are now four possibilities:

1. Laura did take the train and she did arrive at 2pm.
2. Laura did not take the train and she did arrive at 2pm.
3. Laura did take the train and she did not arrive at 2pm.
4. Laura did not take the train and she did not arrive at 2pm.

If Laura did not take the train (in the actual past), the antecedent denotes the empty set, so the conditional is trivially true. If she did take the train and she did arrive at 2pm, the assertion is that within the set of relevant histories containing the actual index at which Laura took the train, all relevant histories contain the actual index at which Laura arrived at 2pm. The two sets are identical, so the conditional is true. If she did take the train but did not arrive at 2pm, the assertion is that within the set of histories containing the actual index, all histories should be such that Laura arrived at 2pm, but in fact, none of the histories in this set has this property, so the conditional is false.

The truth conditions so derived are thus the same as for the material implication. Before I discuss the consequences of this analysis, I will first consider a series of other indicative conditionals to which a similar analysis applies. Consider (27):

(27) If Laura took the train, she is arriving now.

In (27), both clauses refer to the actual past and present. The situation is therefore very much the same as with (25): both clauses denote either H_c or the empty set and the truth conditions match the material implication.

[5] Every quantification over histories and indices comes with a contextual restriction. The variables R_I, R'_I ensure a temporal restriction in addition to the modal one: it is not sufficient that Laura took the train at some point in her life, we are talking about a specific period of time.

[ii] I may have to spell this out in more detail.

These conditionals with a reference to the past or present differ from future indicatives and from counterfactuals in that it is actually possible to empirically verify whether they are true at all. For (25), for example, we can find out whether Laura took the train and whether she arrived at 2pm. These facts will tell us with certainty whether the conditional sentence is true or false. There may be practical difficulties with obtaining that information, but theoretically, these types of conditionals can always be tested against experience. This contrasts with sentences where one or both parts of the conditional refer to the future. Consider the following examples:

(28) If Laura took the train, she will arrive at 2pm.

(29) If Laura takes the train now, she will arrive at 2pm.

(30) If Laura takes the train tomorrow, she will arrive at 2pm.

In (28) and (29), the antecedent refers to the actual past or present, while the consequent refers to possible future. Again, the antecedent denotes either the empty set, in which case the conditional is trivially true; or it denotes the set of histories containing the actual past and present H_c. H_c is by definition also the set of all (relevant) possible futures. In this case, if all relevant futures are such that Laura arrives at 2pm, the conditional is true. If there are relevant futures in which she does not arrive at 2pm, it is false.

This type of conditional is similar to past and present indicatives in that it is automatically true if the antecedent is false. But it differs from them in that we cannot simply empirically falsify it: Suppose Laura takes the train and she does not arrive at 2pm. Does that make the conditional false? Can I call the producer of (29), let's name her Audrey, a liar? Not necessarily. It may be that the history that turned out to be our reality was not among the set of relevant histories that Audrey quantified over in (29). In other words, something unexpected happened. Audrey may perfectly well defend herself by saying, for example, *Laura WOULD have arrived at 2pm, if the train hadn't broken down.* In effect, this utterance points out that the histories considered relevant at the point of uttering (29) have now turned out to contain counterfactual developments. So maybe Audrey was a little overoptimistic in her estimation of the train's reliability, but she can plausibly claim that she was not giving out wrong information.

We cannot even safely assume the truth of the conditional if Laura is in fact taking the train and she does in fact arrive at 2pm – because, even then, we cannot be sure that the course of events that turned out to be our actual reality was among the possibilities considered by Audrey at the point of utterance. For example, suppose that Laura does take the train and she does arrive at 2pm, but only because the train was hijacked by terrorists who ignored all intermediate stops and raced the train to its final destination. Under normal circumstances, the journey would have taken two

more hours. Unless Audrey had reason to assume this would happen, the conditional in (29) is false, because in the histories considered relevant by Audrey, Laura would not have arrived this early and Audrey was wrong to make that assertion.

So for indicative conditionals where the antecedent refers to the past or present and the consequent refers to the future, we need to know which developments were considered relevant by the speaker in order to judge their truth.

Yet another dimension of uncertainty is added when both parts of the conditional refer to the future. In (30), we are quantifying only over future events. Among the relevant futures, we may assume that some are such that Laura takes the train and some are such that she does not take the train. And some relevant futures will be such that Laura does arrive at 2pm while in others she will arrive later or earlier or not at all. In contrast to the other cases, we will therefore not expect a scenario where either the antecedent or the consequent denotes the empty set. This means that, if we want to evaluate the truth of (30) with hindsight, we cannot empirically verify or falsify it at all. This conditional is not automatically true if Laura does not turn out to take the train – because there may be counterfactual developments that were considered relevant possible futures at the time of utterance where she does take the train but fails to arrive at 2pm.

In fact, no matter what actually happens, we can only have evidence about one particular development that may or may not have been among the possibilities that were quantified over at the time of utterance. There is no way to empirically ascertain whether 1) the course of events that turned out to be our actual reality was part of the possible developments that were considered relevant at the time of utterance; and 2) even if it was, we cannot know whether the correlation between the two propositions we experience in our actual reality also holds for the other developments that were quantified over.

No matter what turns out to be the case, we can always argue for or against the plausibility of an utterance such as (30), given the knowledge of the producer at the time of utterance. These clauses do have specific truth conditions. But it is not possible for us to ascertain them empirically. We will see a similar situation with counterfactuals.

Summarizing this section, we have seen that the proposed account predicts truth conditions that match the material implication for indicative conditionals with a past and present reference. Conditionals where the antecedent refers to the past or present, but the consequent refers to the future, are true if the antecedent is false. Otherwise, they can be true or false but we will not be able to empirically determine their truth with certainty. Conditionals where both parts refer to the future are true if the set of relevant histories such that the antecedent is true is a subset of the relevant histories such that the consequent is true. Staying with indicatives of the past and present for the moment, I will now explore their relation to the material implication in more

detail.

4.2.2 Indicative many-worlds conditionals and material implication

As long as we stick with indicative conditionals about the past and present, we get the same truth conditions as the material implication. Does this mean that my account of conditionals is equivalent to the material implication in the context of the actual past and present? Kratzer (1991) cites a proof by Gibbard (1981) according to which any operator $\Rightarrow$ satisfying the following three conditions reduces to the material implication:

Definition 10 *Gibbard's criteria for equivalence of an operator $\Rightarrow$ to the material implication:*

(i) $p \Rightarrow (q \Rightarrow r)$ *and* $(p\&q) \Rightarrow r$ *are logically equivalent.*

(i) $p \Rightarrow q$ *logically implies the corresponding material conditional. That is,* $p \Rightarrow q$ *is false whenever* p *is true and* q *is false.*

(i) If p *logically implies* q*, then* $p \Rightarrow q$ *is a logical truth.*

At this point, I am agnostic about the status of logical truths in the framework I am proposing. But to the extent that there are any, condition (iii) is certainly satisfied. And we have seen before that condition (ii) holds in the context of indicative conditionals of the past and present. Condition (i) is interesting. Remember that we considered two definitions of *if*, 8 and 9. The definition of *if* in 8 is incompatible with a formula such as $p \Rightarrow (q \Rightarrow r)$. This is because this version of *if* takes two expressions of type $\langle s, t\rangle$ as its arguments and yields an expression of type t. So, in an utterance of the form $p_{\langle s,t\rangle} \Rightarrow (q \Rightarrow r)_t$, the antecedent p is of type $\langle s, t\rangle$, but the consequent $q \Rightarrow r$ is of type t. Therefore, the consequent cannot be the second argument of the *if* that we have defined in 8, because it has the wrong type. Definition 9, by contrast, straightforwardly applies to such cases. On the one hand, I tend to agree with the following verdict by Brandom (1981: 129):

> The nesting of conditionals is a construction which is rare enough in natural languages that our intuitions about when such compounds are true are not reliable.

On the other hand, I think that a sentence such as the following are still normal enough that a definition of *if* that can handle them has an edge over one that does not:

(31) If Laura took the train, then, if the train was on time, she arrived at 2pm.

Applying the definition in 9, we get a nested structured proposition of the following form:

(32) $\langle H_p, \langle H_q, \mathfrak{r} \rangle \rangle$, where $\mathfrak{r}$ is the existentially closed version of r.

In words: within the set of histories such that p is true, the set of histories containing an index such that q is true is such that all histories within this set also contain an index such that r is true.

Turning back to Gibbard's condition 1, it is certainly a plausible intuition that (31) is equivalent to (33):

(33) If Laura took the train and (if) the train was on time, she arrived at 2pm.

Intuitively, the logical form of (33) should be somewhat different though, along the lines of (34), and it would not be difficult to define *and* in such a way that allows us to derive this form:

(34) $\langle H_p \cap H_q, \mathfrak{r} \rangle$

In words: Within the intersection between the set of histories such as p is true and the set such that q is true, all histories are such that r is true. Truth-functionally, the two forms are clearly equivalent. In sum, while Gibbard's condition 1 is not trivially true in the proposed framework – because there are no trivial interdefinitions between *if* and *and* or other expressions – we can straightforwardly derive identical truth conditions of the two expressions involved.

I take this to mean that, in the context of indicative conditionals of the past and present, the similarities to the material implication are sufficient to warrant a more detailed comparison. In particular, the material implication as an analysis of natural language conditionals has come into a lot of criticism and we need to see whether the same short-comings also apply to my proposal.

There are different types of criticisms. One crucial question is whether certain cases of conditionals that the material implication would predict to be true but that are clearly bad are in fact false or merely infelicitous. I suggest that the most poignant cases of this kind really only concern counterfactual and future conditionals, whose truth conditions we will find to be different. For past indicatives, I believe that the Gricean approach to the felicity of conditionals is sufficient to account for our intuitions about their meaning. In section 4.2.4, I will argue that the same pragmatic principles also extend to some logical properties of the material implication in conditional arguments.

The third type of criticism involves the problems quantified conditionals identified by Kratzer (1991). Essentially, my proposal is largely analogous to Kratzer's in that respect, although we will see that there are nevertheless important differences, which I will discuss in section 4.2.5.

4.2.3 Truth and felicity

One property of the material conditional that has always bugged philosophers and linguists alike is the fact that the falsity of its antecedent is sufficient for its truth. Consider the following argument by Stalnaker (1968):

> 'To make the question more concrete, consider the following situation: you are faced with a true-false political opinion survey. The statement is, "If the Chinese enter the Vietnam conflict, the United States will use nuclear weapons." How do you deliberate in choosing your response? What considerations of a logical sort are relevant? I shall first discuss two familiar answers to this question, and then defend a third answer which avoids some of the weaknesses of the first two. The first answer is based on the simplest account of the conditional, the truth functional analysis. According to this account, you should reason as follows in responding to the true-false quiz: you ask yourself, first, will the Chinese enter the conflict? and second, will the United States use nuclear weapons? If the answer to the first question is no, or if the answer to the second is yes, then you should place your X in the "true" box. But this account is unacceptable since the following piece of reasoning is an obvious non sequitur: "I firmly believe that the Chinese will stay out of the conflict; therefore I believe that the statement is true." *The falsity of the antecedent is never sufficient reason to affirm a conditional, even an indicative conditional.*' (Stalnaker1968: 100, my emphasis)

Stalnaker (1968) uses a conditional with future reference and he talks about belief rather than knowledge. We have already seen that the truth conditions for future conditionals do not match the material implication in my account below. In my proposal, the falsity of the antecedent only renders those conditionals true whose antecedent refers to the actual past or present.

Does Stalnaker's objection apply to those conditionals, then? Consider the following example discussed by Edgington (1995): Someone asks me where John is, and I know that he is in the bar and that he would never go near a library. However, I want to avoid disclosing that information without resorting to an outright lie. Can I truthfully utter the sentence in (35)?

(35) If John is not in the bar, he's in the library.

The Gricean answer is that this conditional is in fact true, but misleading: The utterance of a conditional is only licensed if I am unsure about both the antecedent and the consequent. Given that I'm certain that John is in the bar, I might as well say so right away. The sentence in (35) is true, but it suggests that I am not certain about John's whereabouts and that both the bar and the library are plausible places to look for him. I concur with this conclusion.

Another example is discussed by Kratzer (1991):

(36) If my hen has laid eggs today, then the Cologne cathedral will collapse tomorrow.

My account predicts that this conditional is true if the antecedent is false. Thus, if I already know that my hen has not laid any eggs, the conditional should be true. Again, I concur with Grice, according to whose account the conditional in the given situation is in fact true, but infelicitous. As in (35), if I know the antecedent clause to be false, I am not supposed to use it in a conditional. Furthermore, combining two clauses in a conditional or another conjoined structure always implicates that there is some meaningful connection between them. Unless I have some theory about how my hen's egg-laying behavior is connected to the stability of the Cologne cathedral, I cannot utter (36) with felicity. But this is part of the implicature that comes with a conditional, not of its truth conditions.

4.2.4 Some logical properties

In this section, I will address some prevalent problems with the material implication that might also concern the logical properties of indicatives. One apparent problem with the material implication is its monotonicity: In the material-implication analysis of indicative conditionals, (37-b) should follow from (37-a):

(37) a. If Laura took the train, she arrived at 2pm.
b. If Laura took the train and the train ran behind schedule, she arrived at 2pm.

My approach to indicatives makes the same prediction. While I agree that this conflicts with basic intuitions, I believe that these intuitions are informed by pragmatic principles and do not derive from the truth conditions per se. In short, I do in fact think that someone who utters (37-a) should also be committed to the truth of (37-b), either because they know that the train was on schedule, or because they know the train was late and the actual time of arrival was 2pm; but they should not have a pragmatic license to utter (37-b). Someone who utters an indicative conditional with a past reference and without further modal modifications should be fairly certain about it. For example, for someone to utter (37-a), we may expect that they know the train ac-

tually arrived at 2pm. Uttering (37-b), however, implies that the speaker is uncertain whether the train was on schedule: The utterance of a conditional always requires that the speaker be uncertain about the antecedent. So, (37-a) requires at least a reasonable degree of confidence about the train's punctuality, whereas (37-b) requires explicit uncertainty about it. This is why someone who asserts (37-a) cannot at the same time also utter (37-b).

Another property discussed by Stalnaker (1968) that, according to him, should distinguish indicative conditionals from the material implication is the invalidity of an inference of contraposition. In Stalnaker's example, it should not be possible to derive (39) from (38), since one may reasonably claim (38) without necessarily agreeing to (39):

(38) If the U.S. halts the bombing, then North Vietnam will not agree to negotiate.

(39) If North Vietnam agrees to negotiate, then the U.S. will not have halted the bombing.

This particular example is about the future, so we do not get the truth conditions of the material implication and an inference of contraposition does not apply: My account would predict that these two sentences can be equivalent, but only if they select the same set of relevant histories. Since the two clauses may well be used to highlight different regularities, it is plausible that the set of relevant histories be constructed differently.[6,iii]

In past contexts, however, my approach does predict that the inference of contraposition should be valid. In the example below, this means that (41-b) follows from (41-a).

[6]Generally speaking, if the antecedent temporally precedes the consequent, the default interpretation is that the antecedent is a cause for the consequent. If the temporal order is reversed, the default interpretation is that the consequent is a piece of evidence to help us find out what happened earlier.

[iii]In fact, I think there is more going on here. I think, (39) is generally weird because this kind of conditional is usually only felicitous if the antecedent holds a clue to what happened previously, which is otherwise hard to determine. Consider the following example:

(40) a. *This spin doctor has been indispensable in the past.* If governing party do not make him fix this mess, they will lose the coming elections.
b. If the governing party wins the coming elections, (this means that) he will have fixed this mess.

I think that someone who utters a) should usually also commit to b). And both sentences are fine. The Stalnaker example is weird because we'll know whether or not the US will have continued the bombing irrespective of whether North Vietnam agrees to negotiate.

(41) a. If Laura took the train, she arrived at 2pm.
b. If Laura did not arrive at 2pm, she did not take the train.

My own intuitions are fine with this prediction. I think that someone who commits to (41-a) also commits to (41-b). Uttering (41-b) may not be relevant in a context that licenses the utterance of (41-a), but in terms of their truth conditions, the two should be identical.

Before concluding this section, let me point out that it is quite easy to form conditionals with a past reference that do not come with the strong implications of the examples discussed above. If I am not entirely sure about the train's arrival time in our go-to scenario, for example, I can easily make a more cautious claim about the relation between Laura's choice of vehicle and her arrival time:

(42) If Laura took the train, she must/ will have arrived at 2pm.

The use of the modal auxiliaries *will* or *must* forces us to take into account the realm of counterfactual developments in processing (42) because it is more complex than the simple past. With both auxiliaries, we get the same truth-conditional meaning: Within the set of contextually relevant histories such that there is an actual past index such that Laura took the train, all histories contain an index such that she arrived at 2pm. Monotonicity and contraposition do not necessarily apply because the corresponding sentences may involve a different setting of the relevance variable. I will return briefly to the comparison between indicative conditionals with and without a modal auxiliary in 4.2.5 below.

4.2.5 Quantified conditionals

Kratzer (1991) concludes that Grice's account of indicative conditionals as material implication plus felicity conditions is quite convincing. The only real problem she identifies in this approach is Grice's paradox. The following is a reproduction from Grice (1967: 78):

> Yog and Zog play chess according to normal rules, but with two special conditions:
>
> (1) Yog has white 9 out of 10 times.
> (2) there are no draws.
>
> To date there have been 100 games.
>
> (1) Yog when white won 80 out of 90.

(2) Yog when black lost 10 out of 10.

They played one of the 100 games last night. The Law of Contraposition states that "if A, B" is equivalent to "if not B, not A". So, seemingly, the probabilities are:

(1) $\frac{8}{9}$ that if Yog had white, Yog won.
(2) $\frac{1}{2}$ that if Yog lost, Yog had black.
(3) $\frac{9}{10}$ that either Yog didn't have white or he won.

Given that (1) and (2) should be equivalent, how can they have different probabilities? Interestingly, the theory proposed here places very strict conditions on how these sentences can be interpreted at all. Crucially, a sentence such as (2) – *the probability is $\frac{1}{2}$ that if Yog lost, Yog had black* – can not mean that the conditional is true in half of all histories. This is because conditionals are not properties of histories. As discussed in section 2.2, their truth is not relative to a particular history or index. What do such sentences mean, then? Kratzer (1991: 653) rephrases sentence in the following way, which seems to be a more natural way to put it:

(43) If Yog lost, there is a probability of $\frac{1}{2}$ that he had black.

Put this way, it is clear that these cases are analogous to the iterated conditionals discussed in section 4.2.2. We are dealing with a conditional of the form $[\![\textbf{if}]\!](p_{\langle s,t\rangle})(\mathfrak{q}_t)$, where $\mathfrak{q}$ is of a different type from p. This combination of arguments is only applicable to the definition in 8, not definition 9. The meaning of (43) is derived in (44):

(44) $[\![\textbf{if}]\!](\lambda i.\textbf{loose}(y)(i), i \in I_{\text{SPAST}})(\frac{1}{2}\{h|h \in R_H\}.\exists i' \in h.\textbf{black}(y)(i'), i' \in I_{\text{SPAST}}) =$
$\langle\{h|h \in R_H.\exists i \in h.\textbf{loose}(y)(i), i \in I_{\text{SPAST}}\}, [\frac{1}{2}\{h' \in R_H\}.\exists i' \in h'.\textbf{black}(y)(i'), i' \in I_{\text{SPAST}}]\rangle$

In words: within the set of histories containing an index such that Yog lost, half of all histories is such that he had black. In effect, this account of a quantified conditional is very close to the proposal by Kratzer (1991). The predicted truth conditions are identical. In both accounts, the role of the antecedent is to restrict the quantifier of the consequent. There are however also a number of fundamental differences. In Kratzer's proposal, *if* does not have any real lexical meaning. It functions as a flag to indicate there is a restrictive clause coming up. In my account, *if* has a straightforward lexical definition and it is in fact a two-place predicate. Moreover, in Kratzer's proposal, counterfactual conditionals differ fundamentally from indicative ones. The same mechanisms and definitions cannot be applied. In my account, as we will see below, the differences between the various types of conditionals derive readily from the same set of definitions.

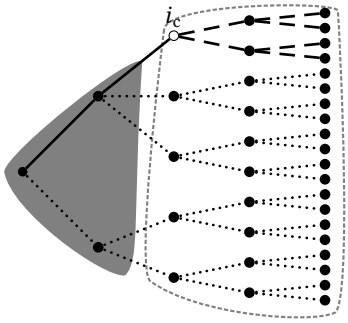

Figure 10: The reference of *must have*

Another difference concerns the treatment of conditional clauses with and without a modal quantifier in the consequent. The basic assumption by Kratzer (1991) is that unquantified conditionals contain a covert modal operator MUST. The difference in interpretation to quantified conditionals with an overt *must* derives from lexical differences between MUST and *must*:

A minimal pair to illustrate this difference is given in below (example (25) is repeated from before):

(25) If Laura took the train, she arrived at 2pm.

(45) If Laura took the train, she must have arrived at 2pm.

The two sentences are no doubt quite similar in their truth and felicity conditions, but it would still appear that (45) is a weaker commitment compared to (44). In my account, the logical forms of the two expressions differ:

(46) $\langle\{h|h \in R_H.\exists i \in R_I.i \in h, \textbf{took.the.train}(l)(i), i \in I_{\text{SPAST}}\}, [\forall h \in R_H.\exists i' \in R'_I.i' \in h, \textbf{arrived}(l)(i'), i' \in I_{\text{SPAST}}, t(i') = 2pm]\rangle$

(47) $\langle\{h|h \in R_H.\exists i \in h, \textbf{took.the.train}(l)(i), i \in I_{\text{SPAST}}\}, [\forall h \in R_H.\exists i' \in h.\exists i''.i'' < i', \textbf{arrived}(l)(i''), t(i'') = 2pm, i' \in I_{\text{MUST}},]\rangle$

The definition of I_{MUST} is taken from [author retracted] (in prep.):

Definition 11 *The meaning of* must
$[\![\textbf{\textit{must}}]\!] = \lambda p \lambda i.p(i), i \in I_{MUST}$, *where* $I_{MUST} = \{i|t(i_c) \leqslant t(i)\}$

The combination of *must* with *have* as defined in 7 refers to the set of indices illustrated in figure 10.

While the simple past can in principle refer to counterfactual indices (compare definition 7), this interpretation is precluded in (25) by the pragmatic principle in definition 4-iii. The contextual variable R_H in (25) is therefore restricted to those histories

containing the actual past and present.

The reference of *must have* also includes the actual past, but principle 4-iii is preempted by the contrast with the simple past, which is less complex than the combination of *must* and *have*. This means that in (45), we cannot simply ignore the counterfactual worlds, the consequent of this utterance quantifies both over the actual and the counterfactual past. The truth conditions of this conditional do not match the material implication – its truth is underspecified by empirical observations.

Moreover, the fact that the producer of (45) forces us to think about counterfactual histories suggests that she has no other option – presumably because she does not have enough information to refer only to the actual past. This is why we get a weaker reading for (45) compared to (25).

Concluding this section, we have seen that indicatives with a past reference share some crucial properties of the material implication. Those objections that apply to both approaches can be resolved satisfyingly with a Gricean account of felicity conditions.

4.3 Counterfactuals

The analysis of counterfactual conditionals is where my approach differs the most dramatically from the tradition. As far as I am aware, no previous account has ever questioned the premise that the truth of counterfactual conditionals can be decided based on empirical observations in the actual world. Yet, the truth conditions that derive from the assumptions I have made so far predict exactly this. Before I discuss the philosophical implications, let us first take a look at this derivational process.

Consider the following sentences:

(48) If Laura took the train, she would arrive at 2pm.

(49) If Laura had taken the train, she would have arrived at 2pm.

With the definitions developed so far in 9 and 7, the meanings of these two sentences are the following respectively:

(50) Within the set of relevant histories that contain an index in the counterfactual present or future such that Laura takes the train, all histories contain an index in the counterfactual future such that she arrives at 2pm.

(51) Within the set of relevant histories that contain an index in the counterfactual past such that Laura takes the train, all histories contain an index in the counter-

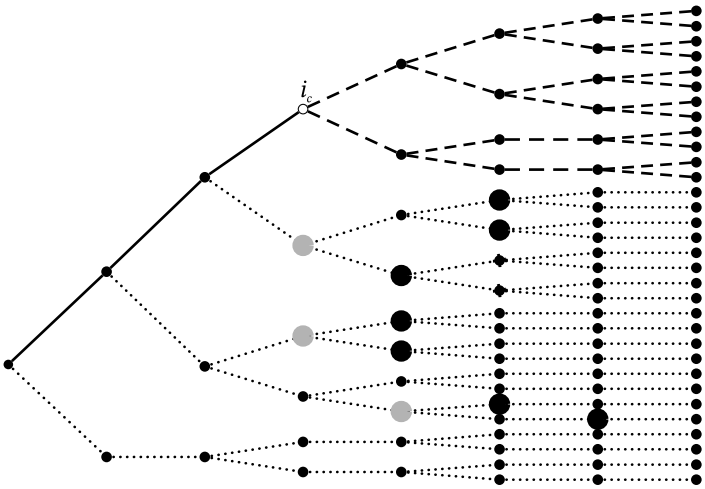

Figure 11: A scenario where the counterfactual clause in (48) is true; big gray dot: an index such that Laura takes the train; large black dot: an index such that Laura arrives at 2pm.

factual past such that Laura arrives at 2pm.[7]

A scenario in which the counterfactual in (48) is true is illustrated in figure 11.

This treatment of counterfactual clauses implies that we can never empirically test whether they are true, because they are statements about counterfactual worlds and we cannot gather evidence in any but the actual world. There appear to be two main reasons why this kind of analysis has previously been rejected. The first reason is a theoretical one: some early authors on the subject have been reluctant to accept the idea that it may be impossible to empirically ascertain the truth of a contingent statement and their preference was never called into question. Stalnaker (1968: 99) states the central question as follows:

> "...many counterfactuals seem to be synthetic, and contingent, statements about unrealized possibilities. But contingent statements must be capable of confirmation by empirical evidence, and the investigator can gather evidence only in the actual world. How are conditionals which are both empirical and contrary-to-fact possible at all ? How do we learn about possible worlds, and where are the facts (or counterfacts) which make counterfactuals true?"

As indicated before, my own response to this question is that conditionals that are both empirical and contrary-to-fact are not possible. I question the premise that con-

[7]Truth-conditionally, both the antecedent and the consequent could also refer to present or future moments, but this interpretation is blocked by the contrast to the less complex form without perfect *have*.

tingent statements must be empirically falsifiable. I am very comfortable with the idea that people say things all the time that can never be completely tested for their truth.

The second reason is more empirical and involves our intuitions about what makes a valid refusal of a counterfactual statement. For the rest of this section, I will review these intuitions and argue that, once again, they tell us more about felicity conditions than about truth conditions of conditionals.

My analysis of counterfactual conditionals predicts that they can be true even if their protasis is true in the actual world and its apodosis is false in the actual world. This is clearly counterintuitive since we can apparently assert the falsity of a counterfactual statement by pointing out contradicting facts in the actual world. Thus, the utterance by speaker B is a perfectly valid way to refute the counterfactual statement uttered by A in the following conversation:

(52) A: If Laura had taken the train, she would have arrived at 2pm.
B: That's not true. Laura did take the train, but she arrived only at 3pm.

What I am going to argue here is not that decades of solid intuitions about the validity of counterfactual arguments such as in (52) are somehow wrong. My claim is rather that B's utterance here is not a direct counterargument against the truth of the counterfactual, but against a very strong pragmatic implicature. This implicature is that the relation between propositions that we claim to hold in relevant counterfactual worlds should also hold in the actual world. In other words, the counterfactual conditional implicates the indicative conditional. For our example above, this means:

(53) a. If Laura had taken the train, she would have arrived at 2pm.
b. $\rightsquigarrow$ If Laura took the train, she has arrived at 2pm.

How does this implicature derive from the counterfactual in (52)? My suggestion is that it follows from basic Gricean principles: *Prima facie*, any statement about counterfactual worlds is grossly irrelevant, since by definition, we have absolutely no way of testing its truth. The only possible justification for talking about counterfactual worlds at all is that, as long as we are talking about worlds that are sufficiently similar to the actual world, we should still be able to draw conclusions about this actual world from what we learn about those counterfactual worlds. The relations between propositions that we claim to hold for relevant counterfactual worlds should in principle also extend to the actual world.

Why, you might ask, do we then use counterfactuals at all, if all we really want to talk about is the actual world and the only reason the counterfactual statement is relevant at all is because of its implicature about the actual world? The reason is that there are cases in which we can assume that an indicative would also not be very

informative, because we are more or less certain that the protasis is false. In these cases, the indicative conditional is trivially true and therefore not informative. The use of an indicative conditional is only licensed if we are uncertain about both the antecedent and the consequent.

So my claim is that the B's objection in (52) is in fact not a contradiction to the truth of A's statement, but to its implicature. I'd like to briefly defend the idea that an objection of the form *that's not true* can in fact be a contradiction to an implicature only rather than the original statement by considering the following two example conversations:

(54) A: If Laura had taken today's 8 o'clock train from Frankfurt, she would have arrived in Berlin at 2pm.
B: That's not true. Mark took that exact train and she arrived only at 3pm.

(55) A: If you had taken melatonin before your flight to Boston last week, you would not have been jet-lagged.
B: That's not true. I took some melatonin before flying to New York last year, but I still had a terrible jet-lag.

In both cases, we may feel that B has made a valid argument against A's claim, despite the fact that it is very clear that B's statement does not refute directly the truth of A's statement: In (54) A didn't make any claim about Mark's time of arrival, only about Laura's. So A would of course be justified to respond to B saying *I didn't say anything about Mark, so how can you say I'm wrong?* but this would pragmatically only be licensed if A could plausibly motivate a claim that two people can take the exact same train and still arrive at the same station at different times. Otherwise, the assumption that Laura should arrive at the same time as Mark is enough to make B's utterance a valid counterargument to A's claim.

A similar case can be made for (55), of course. Again, A would in principle be justified to say *I didn't make a claim about your flight last year/ about flying to New York, so how can you say I'm wrong?*, but only if A can plausibly explain how flying to New York the year before differs from flying to Boston a week ago regarding the efficacy of melatonin.

I suggest that what happens in (52) is analogue to what happens in (54) and (55): B actually only objects to a strong implicature of A's statement, but we accept this objection as a valid contradiction to A's statement as long as A cannot plausibly motivate why the implicature is not valid. This means that in a conversation such as (52), A should have the option to refute B's objection by saying something like *I wasn't talking about the actual world, I was talking about a set of worlds that differs from the actual world by a crucial factor (while still being close enough to the actual world to*

qualify as relevant).

I think that there are situations in which such conversational moves are valid and do in fact take place. Consider the following scenario: Donny and Walter are in prison on remand after drugs have been found in their car. Donny blames Walter for provoking the police officer:

(56) Donny: If you had just showed him your license, we would have gotten away.
Walter: I did show him my license. (We did not get away).
Donny: I mean, if you had showed him your license *before* he got suspicious and searched the car.

As before, Walter's statement is intuitively a valid objection to Donny's statement. However, Donny's response also appears to be a valid rebuke to Walter's objection. What happens here, I believe, is that Walter's objection forces Donny to clarify the set of worlds that he is quantifying over. Donny defends the validity of his claim by pointing out an important difference between the worlds he was quantifying over and the actual world, even though this difference is not made explicit by his original statement (possibly because he considers it self-evident). The original implicature from the counterfactual conditional to an indicative conditional can thus be cancelled; the relevance requirement means that it be replaced by the new implicature that derives from the more specific condition in Donny's rebuke.

5 Other aspects

1. determinism; different levels of parallel universes
2. aspect
3. iterated modalities
4. sequence of tense
5. Ogihara cases

6 Conclusion

In this paper, I have argued that we can, in effect, do formal semantics without doing logic in the narrow sense. I have tried to show that in giving up some of the assumptions on which standard logic is based, we can develop an analysis of natural language expressions that is far more straightforward and simple than previous approaches. We end up with an understanding of modal expressions and conditional clauses whose interpretation relies far more on pragmatic principles than previously

conceded.

References

Abusch, Dorit. 1997. Sequence of tense and temporal de re. *Linguistics and Philosophy*, **20**, 1–50.

Arregui, Ana. 2009. On similarity in counterfactuals. *Linguistics and Philosophy*, **32**, 245–278.

Arregui, Ana. 2010. Detaching *if*-clauses from *should*. *Natural Language Semantics*, **18**, 241–293. 10.1007/s11050-010-9055-5.

[author retracted]. in prep.. When the mood is tense.

Belnap, Nuel. 2012. Newtonian determinism to branching space-times indeterminism in two moves. *Synthese*, **188**, 5–21.

Brandom, Robert. 1981. Semantic paradox of material implication. *Notre dame journal of formal logic*, **22**(2), 129–132.

Broekhuis, Hans, & Verkuyl, Henk J. 2013. Binary tense and modality. *Natural language and linguistic theory*, **32**(3), 973–1009.

Condoravdi, Cleo. 2002. Temporal interpretation of modals: Modals for the present and for the past. *Pages 59–88 of:* Beaver, David, Casillas, L., Clark, Brady, & Kaufmann, Stefan (eds), *The construction of meaning*. Stanford, CA: CSLI Publications.

Condoravdi, Cleo, & Kaufmann, Stefan. 2005. Modality and temporality. *Journal of Semantics*, **22**, 119–128.

Copeland, Jack B. 2006. Meredith, Prior, and the history of possible worlds semantics. *Synthese*, **150**, 373–397.

Copley, Bridget. 2009. *The semantics of the future*. New York, London: Routledge.

Dowty, David. 1977. Toward a semantic analysis of verb aspect and the English 'imperfective' progressive. *Linguistics and philosophy*, **1**, 45–77.

Dowty, David. 1979. *Word, meaning and Montague grammar*. Dordrecht: Reidel.

Edgington, Dorothy. 1995. On conditionals. *Mind*, **104**(414), 235–329.

Fernando, Tim. 2008. Branching from inertia worlds. *Journal of semantics*, **25**, 321–344.

Fleischman, Suzanne. 1982. *the future in thought and language*. Cambridge University Press.

Gibbard, Allan. 1981. Two recent theories of conditionals. *Pages 211–247 of:* Harper, William, Stalnaker, Robert, & Pearce, Glenn (eds), *Ifs: Conditionals, belief, decision, chance and time*. Dordrecht: Kluwer.

Grice, H. Paul. 1967. *Logic and conversation: The William James lectures*. reprinted in ?.

Groenendijk, Jeroen, & Stokhof, Martin. 1982. Semantic analysis of *wh*-complements. *Linguistics and philosophy*, **4**, 175–233.

Haiman, J. 1978. Conditionals are topics. *Language*, **54**(3), 564–589.

Hinterwimmer, Stefan, Ebert, Christian, & Endriss, Cornelia. 2008. A unified analysis of indicative and biscuit conditionals as topics. *Pages 266–283 of: Proceedings of Semantics and Linguistic Theory (SALT)*, vol. 18.

Iatridou, Sabine. 2000. The grammatical ingredients of counterfactuality. *Linguistic Inquiry*, **31**(2), 231–270.

Ippolito, Michela. 2013. *Subjunctive conditionals: a linguistic analysis*. Linguistic Inquiry Monograph, vol. 65. Massachussetts Institute of Technology.

Kamp, Hans, & Reyle, Uwe. 1983. *From discourse to logic*. Dordrecht: Kluwer.

Kaufmann, Stefan. 2005. Conditional truth and future reference. *Journal of Semantics*, **22**, 231–280.

Klein, Wolfgang. 1994. *Time in language*. London, Berlin: Routledge.

Kratzer, Angelika. 1991. Conditionals. *Chap. 30 of:* von Stechow, Arnim, & Wunderlich, Dieter (eds), *Semantics: An international handbook of contemporary research*. Walter de Gruyter.

Laca, Brenda. 2012. On modal tenses and tense modals. *Pages 171–194 of:* Nishida, Ch., & Russi, C. (eds), *Building a bridge between the linguistic communities of the Old and the New World. current research in tense, aspect, mood and modality*. Cahiers Chronos, no. 25. Amsterdam: Rodopi.

Lassiter, Daniel. 2014. The weakness of *must*: In defense of a mantra. *Pages 597–618 of: Proceedings of salt*, vol. 24.

McArthur, Robert P. 1974. Factuality and modality in the future tense. *Noûs*, **8**(3), 283–288.

Meredith, Carew Arthur, & Prior, Arthur Norman. 1956. *Interpretations of different modal logics in the "property calculus"*. mimeograph, University of Canterbury Philosophy Department, reprinted in **?**.

Ogihara, Toshiyuki. 2000. Counterfactuals, temporal adverbs, and association with focus. *Pages 115–131 of:* Jackson, Brendan, & Matthews, Tanya (eds), *Proceedings of salt x*. Ithaca, NY: Cornell University.

Placek, Tomasz, & Müller, Thomas. 2007. Counterfactuals and Historical Possibility. *Synthese*, **154**(2), 173–197.

Portner, Paul. 2003. The (temporal) semantics and (modal) pragmatics of the perfect. *Linguistics and philosophy*, **26**, 459–510.

Portner, Paul. 2011. Perfect and progressive. *Pages 1217–1261 of:* Heusinger, Klaus von, Maienborn, Claudia, & Portner, Paul (eds), *Semantis*. Handbücher der Sprach- und Kommunikationswissenschaft. de Gruyter.

Prior, Arthur Norman. 1967. *Past, present and future*. Oxford University Press.

Reichenbach, Hans. 1947. *Elements of symbolic logic*. Macmillan.

Romero, Maribel. 2014. 'fake tense' in counterfactuals: A temporal remoteness approach. *Pages 47–63 of:* Crnič, Luka, & Sauerland, Uli (eds), *The art and craft of semantics: A Festschrift for Irene Heim*. MITWPL, vol. 71. Massachussetts Institute of Technology.

Sabbadin, Michela, & Zanardo, Alberto. 2003. Topological aspects of branching-times semantics. *Studia logica*, **75**, 271–286.

Schulz, Katrin. 2010. Troubles at the semantics/syntax-interface: Some thought about the modal approach to conditionals. *Pages 388–404 of:* Prinzhorn, Martin, Schmitt, Viola, & Zobel, Sarah (eds), *Proceedings of sinn und bedeutung*, vol. 14.

Schulz, Katrin. 2014. Fake tense in conditional sentences: a modal approach. *Natural language semantics*, **22**, 117–144.

von Fintel, Kai. 1997. Bare plurals, bare conditionals and *only*. *Journal of semantics*, **14**, 1–56.

von Fintel, Kai. 1999. Npi-licensing, strawson-entailment, and context-dependency. *Journal of semantics*, **48**(191), 209–214.

von Fintel, Kai. 2001. Counterfactuals in a dynamic context. *Pages 123–152 of:* Kenstowicz, Michael (ed), *Ken hale: a life in language,*. MIT Press.

von Fintel, Kai, & Gillies, Anthony S. 2010. *Must*...stay...strong! *Natural language semantics*, **18**, 351–383.

von Fintel, Kai, & Iatridou, Sabine. 2002 (November). *If and when* if-*clauses can restrict quantifiers*. Unpublished manuscript, MIT written for the Workshop in Philosophy and Linguistics at the University of Michigan.

Stalnaker, R. 1968. A theory of conditionals. *In: Studies in logical theory, american philosophical quarterly*. Dordrecht: D. Reidel. Reprinted in **?**. Page references to **?**.

Tedeschi, Philip. 1981. Some evidence fo a branching-futures semantic model. *In:* Tedeschi, Philip, & Zaenen, Annie (eds), *Tense and aspect*. Syntax and Semantics, no. 14. New York: Academic Press.

Tegmark, Max. 2014. *Our mathematical universe: My quest for the ultimate nature of reality*. Knopf.

Thomason, Richmond, & Gupta, Anil. 1980. A theory of conditionals in the context of branching time. *The philosophical review*, **89**(1), 65–90.

Thomason, Richmond H. 1984. Combinations of tense and modality. *Handbook of philosophical logic*, **2**, 135–165.

Ultan, Russel. 1978. The nature of future tenses. *Pages 83–123 of: Universals of human language*, vol. 3.

von Fintel, Kai, & Heim, Irene. 2005. *Intensional semantics. lecture notes*.

Werner, T. 2006. Future and non-future modal sentences. *Natural Language Semantics*, **14**, 235–55.

Zimmermann, Thomas Ede. 1989. Intensional logic and two-sorted type theory. *The journal of symbolic logic*, **54**(1), 65–77.