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*What If*s*

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Abstract We develop a dynamic account of *what if* questions on which they re-pose questions inside local contexts introduced by their *if*-clauses subject to the felicity constraint that the resulting context is inquisitive. While this analysis is directly motivated by cases where a *what if* questioner challenges another speaker's attempt to answer a current question under discussion (QUD) by seeming to re-ask this question over a more restricted contextual domain, it can also explain the flexibility of *what if* since other uses trigger accommodation with new QUDs to ensure that the post-suppositional inquisitivity condition is met. While QUD accommodation is a complex phenomenon that isn't specific to just *what if* constructions, the pragmatic flexibility of *what if* furnishes a nice range of examples for investigating such repair. In the latter part of the paper, we focus on practical *what if* questions which trigger accommodation with QUDs that subserve the real-world domain goals of the speakers. We offer a systematic working theory of this accommodation within a formal model of discourse that involves *goal stacks* populated with both questions and decision problems tethered together by relevance. The larger contribution of this paper is to add to the understanding of how discourse felicity and update conditions at the level of speech acts can be encoded in natural languages.

Keywords: pragmatics, conditionals, discourse, speech acts, questions, suppositions

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1 Introduction

Research at the semantics-pragmatics interface has progressed greatly in recent years by developing formal accounts of the discourse effects of different speech acts (see for example Farkas & Bruce 2010, Condoravdi & Lauer 2012; among others), as well as the diverse variety of discourse particles (Farkas & Bruce 2010, Kramer & Rawlins 2009, 2010, Zimmermann 2011, Krifka 2013, Roelofsen & Farkas 2015, Goodhue & Wagner 2018; among others), and other left-peripheral morphology found across languages. This paper contributes to the larger project of understanding how semantic-pragmatic interface constraints can be encoded in natural language by examining in depth an understudied non-canonical question type: the case of English *what if*.

The central puzzle is that *what if* questions are versatile enough to defy simple categorization. Most prominently, they are a characteristic method of initiating new discussion about what the world might be like, or might have been like, under some hypothetical set of circumstances, intuitively as a kind of question:

(1) What if Napoleon had won at Waterloo?

(2) A: What if cats could text?
B: They'd be constantly messaging about food.
B′: They'd demand even more attention.

(3) What if the singularity already happened?

However, beyond this, one can ask a *what if* question to challenge or resist a prior utterance, to suggest a course of action in response to a planning question, to tentatively answer a theoretical question, and more. What does a formal account of the interpretation of *what if* at the semantics-pragmatics interface look like that can account for this flexibility? As a trigger for this puzzle, *what if*s fit into a larger family of "discourse conditionals" including those formed with *and if*, *even if*, and *what about if* that all, in subtly different ways, illustrate pragmatic flexibility.

Given the prevalence of *what if* questions in discourse, not to mention other discourse conditionals, it is surprising that such constructions have received almost no prior attention from linguists and philosophers of language — to our knowledge, the only previous analysis of *what if* is in Rawlins 2010.[1] That account explicitly punted on the challenge of pragmatic flexibil-

[1] Edgington 2003 and Starr 2014 have papers titled "What if? Questions About Conditionals" and "What 'If'?" respectively but these are only about *if*, not *what if*. Rescher 2005 also

ity, dealing with only two of the many ways that the *what if* construction can be used. The lack of attention to *what if* is also surprising given that *what if* questions lie at the intersection of two flourishing areas of research: the semantics and pragmatics of *questions* (Hamblin 1958, 1973, Karttunen 1977, Groenendijk & Stokhof 1984, Heim 1994, Krifka 2001, Ciardelli, Groenendijk & Roelofsen 2018; among many others) and *conditionals* (Ramsey 1929, Stalnaker 1968, 1975, Lewis 1973, 1975, Adams 1975, Heim 1983, Veltman 1985, Kratzer 1986, Edgington 1986, 1995, Jackson 1987; among many others). That said, *what if*s raise issues that have been much less studied in both of these literatures: for question acts, their non-canonical form raises issues about what the limits might be for the category of linguistic questions, and for conditionals, *what if*s force us to confront questions about how conditionality relates to discourse structure.

To account for the senses in which *what if*s are question-like and conditional-like, we analyze them in a dynamic model of discourse that tracks the current assumptions of the conversational participants along with the questions they are currently busy discussing (Questions Under Discussion (QUDs); Roberts 1996, 2012b, Ginzburg 1996, van Kuppevelt 1996, Büring 2003) and the salient real-world domain goals that these questions subserve (as in Roberts 2004, 2012a, 2015, 2018). Our rough proposal is that *what if* questions serve to re-pose QUDs inside the local subordinate contexts introduced by their *if*-clauses (where the speakers are assuming these *if*-clauses hold) subject to the felicity condition that the resulting context is *inquisitive* (Groenendijk 1999, Rawlins 2010). This post-suppositional inquisitivity requirement is key to explaining the full range of interpretations, as we argue that many *what if*s trigger accommodation with new QUDs to ensure that the context reaches an inquisitive state, and this repair mechanism is in many cases constrained by the domain goals of the speakers. While in this paper we have space and time to deal with only one case of discourse conditionals, the pieces of the proposal for *what if*s provide a starting point for analyzing the whole family, and, more generally, contribute to our understanding of what kinds of discourse constraints at the semantics-pragmatics interface can be encoded into natural language morphology.

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has a book titled *What If? Thought Experimentation in Philosophy* but this is about thought experimentation in philosophy (big surprise) rather than the semantics and pragmatics of *what if*.

2 The many functions of *what if*

We will have more to say by way of introduction in a moment. But let us first survey some of the functional heterogeneity of *what if*. We have already seen some typical "hypothetical" uses of *what if* in (1)–(3). The XKCD *what if* blog provides many more examples with detailed, scientifically-grounded answers:[2]

(4) What if I tried to re-enter the atmosphere in my car? (a 2000 VW Jetta TDI)

(5) What if you built a siphon from the oceans on Europa to Earth? Would it flow once it's set up?

(6) What if you strapped C4 to a boomerang? Could this be an effective weapon, or would it be as stupid as it sounds?

Such hypothetical *what if* questions are asked discourse-initial in order to start a fresh line of speculation about some new (often non-factual) topic; this initial topic can be narrowed by follow-up questions as in (5) and (6). The questioner is interested in what things are or would be like in the scenario introduced by the *if*-clause.

However, *what if* has multiple other uses besides the discourse-new hypothetical. For instance, an "elaborative" *what if* question can be used following an assertion or some other informational contribution to ask about the consequences of a situation previously described under the assumption contributed by its *if*-clause. These elaborative *what if*s can occur both same-speaker and cross-speaker:

(7) I heard that Alfonso's going to the party. What if Joanna is there?

(8) A: A host of nightmarish insects are in there.
B: What if they get out? (based on narrative text in COCA[3])

[2] http://what-if.xkcd.com

[3] Corpus of Contemporary American English (Davies 2008–): available online at http://corpus.byu.edu/coca/

(9) A: Alfonso's coming to the party.
B: Uh oh, what if Joanna is there?

Similarly, in each of the following exchanges where A wants to hear more about a salient topic, she asks an elaborative *what if* to zoom in on a specific case that has not yet been addressed by B's assertion:[4]

(10) A: How can I get to Amsterdam on time?
B: There's a train leaving on platform 4 in 30 minutes.
A: OK. What if the train is full?

(11) A: Does this medicine have any side-effects?
B: Not in the prescribed dosage.
A: OK. But what if I accidentally take too much?

Such elaborative *what if*s are like discourse-new hypothetical uses but require an informational antecedent that sets the stage, and so are often more limited in scope.

Next up, a *what if* question can be asked following an assertion to challenge or *resist* the speaker's attempt to update the discourse context with the proposition expressed (Rawlins' 2010 "conversational backoff", Bledin & Rawlins' 2016 "resistance moves"). In the following examples, the resister thinks that the resistee might be overlooking some relevant possibility that bears on her proposal, and the resister wants to hear more about this before making a call on acceptance or rejection:

(12) A: Alfonso's coming to the party.
B: What if Joanna is there? (Are you sure?)

(13) A: Are you coming to the party later?
B: Nope.
A: What if Joanna is there? (Are you sure?)

It is instructive to compare (12) with (9). The *Uh oh* in (9) signals that B has accepted A's claim and is now curious about what will happen if both Joanna and Alfonso attend. In contrast, when B challenges A in (12), B has not yet accepted A's claim and is effectively asking if Alfonso will still come to the party if Joanna is there.

[4]Thanks to Ivano Ciardelli (p.c.) for suggesting these examples.

Offers, commands, requests, invitations, etc., as well as biased and even some non-rhetorical questions can also be challenged in this way:[5]

(14) The boy came right over and boldly proposed that, since they were both there at the same time every week, they could start sharing a paper and save a tree. "What if we both want the same section?" Pip said with some hostility. (COCA)

(15) "Push it open, then step away." "What if it's locked?" Peggy said. (COCA)

(16) "Hey, maybe the squirrel is underneath those trash bags. Stir it up a bit." "Not funny, what if it attacks?" (COCA)

(17) A: Why would anybody ever talk to Urkel?
B: What if he has something interesting to say?

(18) A: How can we get to the party?
B: What if there's a cover charge? (You sure you want to go?)

These "challenging" or "resisting" *what if*s are cross-speaker response moves that stall an existing stream of discourse. By bringing up new possibilities or issues, they can serve as enticements for the challenged speaker to change her mind.

Finally, there are also "suggestive" uses. Besides their exploratory and challenging functions, *what ifs* can be used to offer resolutions to salient questions under discussion (QUDs). These suggestive *what if*s come in both practical and theoretical flavors. After a planning question, a hearer can propose a course of action:[6]

(19) A: How can we get to the party on time?
B: What if you finally stop worrying about damaging your new Ferrari and drive?

[5]Thanks to Cleo Condoravdi (p.c.) for bringing the data involving imperatives to our attention.

[6]Though we focus on planning *what if*s following explicit questions in this paper, such *what if*s can also follow assertions and other non-interrogative speech acts:

(i) A: I was going to bake a cake but I haven't got any eggs.
B: What if you make shortbread instead? (based on Franke & de Jager 2010)

Like hypothetical *what if*s, planning *what if*s can also be discourse-initial:

(ii) What if we blow this taco stand and go to the movies?

(20) A: How can I get up to Harlem?
B: What if you take the A-train?

(21) A: Who should we invite to speak at the next colloquium?
B: What if we invite Professor Plum?

These planning *what if*s are also possible same-speaker:

(22) How can I get to my meeting on time? What if I jump in a taxi?

In brainstorming sessions and other collaborative environments, *what if*s can also be used to tentatively offer answers to more theoretical questions, or to suggest that a presupposition of a question is not met:

(23) A: Who could possibly be the murderer?
B: What if the butler lied about his alibi?

(24) A: Where is Phyllis? Why isn't she here yet?
B: What if she's stuck in traffic?

(25) A: Who is coming to the party?
B: What if it was canceled?

Such suggestions can also sometimes happen same-speaker:

(26) I also really like this beautiful, soft purse with silver inserts, but something about it perturbs me. Who is the craftsman? What if it's Emma? (COCA; narrative text)

Note that in cases like (19), B's primary motivation can simply be to put a possible resolution of A's initial question on the table, and B needn't be interested in exploring what things are like if his proposed answer is actual. It would be extremely odd for A to follow up (19) like this:

(27) B: What if you finally stop worrying and drive your new Ferrari?
A: Well, I'll first open the door to my Ferrari. Then I'll get into the driver's seat. Next I'll let you in. Then I'll lower the emergency brake. Then I'll step on the gas. Etc.

Pedantry aside, this misunderstands the point of B's utterance, which is just to bring up the option of driving to the party.[7]

[7]We include (27) for rhetorical reasons. Admittedly, A *can* reply to B's suggestive *what if* by describing what things would be like if he drives when these details are relevant to the shared domain goal of making it to the party on time. We return to this point in Section 4.6.

Type	Primary function	Discourse antecedent
Hypothetical	open up a new general line of speculation	none
Elaborative	ask for some additional information	informational
Challenging	resist hearer's proposal to update the context	varied
Suggestive	suggest a plan of action or answer to open issue	typically a question (must be open QUD)

Table 1 Taxonomy of *what if* types

Now, there are other uses of *what if* that do not slot neatly into one of the above four categories.[8]But we will focus on the taxonomy summarized in Table 1. As mentioned earlier, our central puzzle is to offer a formal account of *what if*s that can account for this flexibility.[9]

In more detail now, we begin our attempt to solve this puzzle in Secion 3 by reviewing some data suggesting that *what if*s are syntactically root-clause-sized idioms. In Section 4, we turn to the semantics of *what if* and develop our proposal from Section 1 that *what if* questions re-pose QUDs in subordinate contexts introduced by their *if*-clauses, where these contexts must be inquisitive in the aftermath of the *what if*. This analysis is directly motivated by challenge cases like (13), repeated as (28) below, where the *what if* questioner seems to be re-asking a QUD explicitly raised in prior discourse

[8]For instance, a speaker can use a *what if* question to domain-restrict a question that she has previously asked:

(i) Is Alfonso going to the party? What if Joanna is there?

[9]Of course, *what if* questions are certainly not the only linguistic vehicle available for resisting, making tentative suggestions, and so forth. Various other kinds of conditional-ish questions and modal constructions can also do these jobs:

(i) A: How can we get to the party? We're going to be late.
B: Even if we borrow Alfonso's car?
B′: {What/How} about borrowing Alfonso's car?
B″: We might be able to borrow Alfonso's car.
B‴: Might we be able to borrow Alfonso's car?

conditionalized on the supposition contributed by the *if*-clause of the *what if* question:

(28) A: Are you coming to the party later?
B: Nope.
A: What if Joanna will be there?

We present two different implementations of our proposal. On the first version developed in Sections 4.1–4.4, which expands on the earlier account of Rawlins 2010, we treat *what if* questions as *conditional questions* (CQs), in the sense of Isaacs & Rawlins 2008. Construed as a CQ, A's challenge in (28) can be decomposed into two steps: an assumption step that triggers a subordinate context in which it is temporarily assumed that Joanna will be at the party, followed by a questioning move that re-asks the QUD (*Is B coming to the party later?*) in this local context. In Section 4.5, we then offer a pared-down version of our proposal on which *what if*s are consequent-less *suppositional questions* (SQs) that involve only the former assumption update; technically, there is no re-asking. Crucially, while the constitutive function of *what if* on the bare-bones SQ account is simply to make a supposition, we still require that *what if* questions have a felicity condition, common to questions in general, requiring that the posterior context is inquisitive, and this ensures that there is an open QUD available for consideration after the update.

Though we present some reasons for preferring this second minimal version of our proposal, the CQ and SQ analyses are quite closely related and much of what we say in the remainder of the paper doesn't depend on the choice between them, so we ultimately leave both the CQ and SQ options on the table. In Section 4.6, however, we reject a third option according to which *what if*s are not even, properly speaking, questions — there is no requirement that they render the context inquisitive — but are rather *suppose* statements in disguise. This purely suppositional story goes too far: we argue that *what if* questions must have both suppositional and questioning aspects, where these aspects can be spelled out by treating these constructions as either conditional or suppositional questions.

Now, whether one goes the CQ or SQ route, one can easily account for the challenging uses of *what if* in cases like (28) that these analyses were designed to handle. However, as we discuss in Section 5, other uses of *what if* pose a prima facie problem for either analysis. First, hypothetical and some elaborative *what if*s are problematic because these questions can be asked when the local overtly triggered QUD is closed or there is no obviously open

QUD at all to be re-asked or re-posed in the local context created by the *what if* update. So it is not immediately clear how the questioning comes about.[10] Second, even when *what if*s directly respond to a prior explicit question, they often do not seem to be re-asking or re-posing this question over a restricted domain. For instance, in the suggestive exchange (21), repeated as (29) below, B does not seem to be asking the rather odd question of whom they should invite to speak on the assumption that they will invite Professor Plum.[11] Rather, he seems to be inquiring about what would happen if they invite Professor Plum in respects that matter for their common goal of having an interesting, well-attended colloquium.

(29) A: Who should we invite to speak at the next colloquium?
B: What if we invite Professor Plum?

Here, too, a flat-footed application of the conditional or suppositional question account delivers a bad result.

This is where the post-suppositional inquisitivity requirement present in both the CQ and SQ accounts comes into play. We argue that in many, if not all, of the problematic cases where there is no QUD available for re-posing or the *what if* questioner seems to pose a totally different question than the current discourse topic, hearers will respond to the *what if* question by accommodating with a new QUD to ensure that the inquisitivity constraint is satisfied — for instance, a hearer might respond to one of the hypothetical *what if*s in (1)–(3) by implicitly raising the "Big Question" (Roberts 1996) or some suitable coarsening of it (though more on this in Section 5). The remainder of the paper is devoted to clarifying this repair mechanism. It is worth emphasizing at the onset that QUD accommodation is a complex phonemenon that isn't specific to *what if* questions, even if it is necessary for an account of *what if*s. So, in a sense, this latter part of the paper isn't just about *what if*s. However, the *what if* construction provides a nice gateway into the problem of QUD accommodation because its pragmatic flexibility furnishes a broad range of examples for investigating this kind of repair, and we often have reasonably clear intuitions in these examples about which question is being accommodated.

It is difficult to be very precise about how QUD accommodation works in general — like accommodation in other domains, it is a messy business —

[10] Examples like (15) where the questioner resists a discourse-new imperative are similarly problematic unless imperatives introduce new QUDs. We have more to say about this in Section 7.

[11] The challenging use in (18) raises a similar difficulty.

but we think that a nice story can be told in many cases where the implicitly introduced QUD subserves the practical goals and interests of the speakers. To provide a more systematic working theory of the repair in such cases, we extend our formal model of discourse in Section 6 by introducing *goal stacks* loaded up with both question denotations (encoding the speakers' *discourse goals* of resolving QUDs) and *decision problems* (encoding their *domain goals* like arranging a successful talk, acquiring a newspaper, and so forth; van Rooy 2003b, Davis 2009, Franke & de Jager 2010, M. Kaufmann 2012, Malamud 2012, Cariani, Kaufmann & Kaufmann 2013). With this decision-theoretic structure in place, we can formulate a new 'Subservience' constraint between the questions and decision problems on a goal stack that captures how the questions that speakers ask in practical contexts depend on their domain goals and plans. In Section 7, we apply Subservience to an example where a *what if* question is used to challenge a discourse-new command — which must trigger QUD accommodation on the assumption that such commands do not introduce or respond to QUDs—and we show how this relevance constraint narrows the range of accommodation options. In Section 8, we then revisit the colloquium example (29) and show how Subservience helps to constrain the repair in this example as well. We conclude in Section 9 with some open problems.

3 The structure of *what if*

Before presenting the core of our analysis, let us first introduce some additional data bearing on the structure of *what if* questions.[12] These data suggest that *what if* is a sentential idiom, albeit with a normal compositionally interpreted *if*-clause.

First of all, the *what* in *what if* is idiosyncratic. The immediate right-attachment of an *if*-clause is restricted to *what*:

(30) What if we invite Joanna?

(31) *{Who/When/How/Why/Where} if we invite Joanna?[13]

[12] Some of the data were first presented in a 2010 WCCFL talk by Rawlins.

[13] There are theatrical exceptions involving negation — *who if not us?*, *when if not now?*, *how if not thus?*, etc. — but we will set these aside. We also set aside clear cases of ellipsis:

(i) A: I'm going to the concert tonight.
B: How, if your car is broken?

This is in mild contrast with *what/how about* questions that work with both *what* and *how* but not the other wh-items:

(32) {What/How} about if we invite Joanna?

(33) *{Who/When/Why/Where} about if we invite Joanna?

And, of course, this is in stark contrast to all sorts of other constituent questions that support the full range of wh-items.

The idiosyncrasy of *what* in *what if* is also suggested by data showing that it cannot undergo normal wh-modification (these tests are due to Baker 1968, 1970; see also Gawron 2001 and Rawlins 2008):

(34) a. *What else if Joanna shows up?
b. *What {the hell/on earth} if Joanna shows up?

(35) a. What else would happen if Joanna shows up?
b. What {the hell/on earth} would happen if Joanna shows up?

The modification data suggest that unlike the *what* in *what would happen if ...* constructions, the *what* in *what if* is not present with its normal meaning and morpho-syntactic properties. (In *what would happen if*, we take the *what* to be a regular wh-item abstracting over abstract entities that serve as the external arguments to the verb *happen*.)[14]

Turning now from *what* to *if*, the first thing to observe is that the *if*-clause is required. One cannot say this:

(36) Suppose we find out that Dimitri is a spy. *What?[15]

By contrast, *suppose* sentences and *if*-clauses can serve as antecedents for related interrogatives:

(37) Suppose we find out that Dimitri is a spy. {Then what?/What then?/What would happen?}

(38) If Dimitri turns out to be a spy, {then what?/what then?/what would happen?}

Note that this requires a comma/heavy intonational break. Note also that *how, if?* is not as versatile as *what if*; the former has only challenging and elaborative uses.

[14]The same points apply to other candidate full conditional question paraphrases like *What would the world be like if...?* and *What would be true if...?*

[15]This is not to say that bare *what?* doesn't have its uses in some (confrontational) discourse contexts.

Moreover, the externals of the *if*-clause are non-standard. In contrast with *what would happen if* constructions, one cannot intervene with *only* or *even* (von Fintel 1994, a.o.):

(39) What would happen {only/even} if Trump gets impeached?

(40) *What {only/even} if Trump gets impeached?

Furthermore, one cannot replace the *if*-clause with a wh-clause to form an unconditional despite arguments in the literature that the wh-adjuncts of unconditionals have the same syntax as *if*-adjuncts (Rawlins 2008, 2013, among others):

(41) What would happen whether or not we invite Joanna?

(42) *What whether or not we invite Joanna?

And one cannot substitute in other complementizers:

(43) *What when a farmer owns a donkey?

(44) *What if and when Joanna graduates?

These last data points are slightly surprising, as *when* patterns with *if* in many ordinary contexts.

On the other hand, the internals of the *if*-clause seem normal up to and including the *if* itself. The characteristic features of regular *if*-clause adjuncts carry over to the *if* in *what if* as well. For example, one can use the past perfect or subjunctive mood to indicate counterfactuality:

(45) What if it {had snowed/were snowing}?

They allow for fake past tense (Iatridou 2000, Schulz 2014):

(46) How can we get to Broek in time? What if we biked?

(47) What if you flew to Amsterdam?

And there are attested examples of NPIs licensed inside *what if*s (cf. von Fintel 1999, among many others):[16]

(48) What if there were any significant side-effects to penicillin in humans (as there are in guinea pigs)? (COCA)

[16]Thanks to Dan Lassiter for asking us about this, and to Nate Charlow and Michela Ippolito for helpful discussion.

(49) What if she ever got mugged? She is a New Yorker and that means she has a contingency plan. (COCA; re Sigourney Weaver)

Admittedly, *what if* isn't a perfectly hospitable environment for NPIs:

(50) ??What if the students have ever been to Rome?

It is generally much easier to embed NPIs in regular adjoined *if*-clauses in whole conditionals. So there is clearly more to say here. However, we suspect that further investigation of the NPI data would tell us more about NPI licensing in conditionals than about *what if*s per se.

Finally, the entire *if*-clause in a *what if* construction can be disjoined, suggesting that it consists of a regular CP headed by regular *if* (thanks to Floris Roelofsen p.c. for this observation):

(51) What if Carlsen plays rook h8 or if he plays queen a5?

So what does our mini-syntactic investigation add up to?[17] The data taken as a whole suggest:

- The internals of the *if*-clause, up to and including *if* itself, have the syntax of a normal tensed compositional CP-sized clause.
- *What if*s are syntactically root-clause-sized idiom chunks where the *what if* sub-sequence is fixed by the idiom; in particular, the idiom selects a CP headed by *if*.

Going forward, then, we will pursue an analysis of *what if* that needn't involve regular *what*. But we will require that *what if*s are *iffy* in the sense that

[17]The whole *what if* construction is subject to some external constraints as well. These questions are generally unembeddable (except on quotative readings):

(i) *Alfonso wondered what if it rained.

(ii) Alfonso wondered, 'what if it rained?'

(iii) Alfonso wondered what would happen if it rained.

In addition, whereas *what if*s can be modified by speaker-oriented adverbs, they cannot combine with *slack regulators* (Lasersohn 1999) or be modified by other lower classes (Cinque 1999, Ernst 2002):

(iv) Seriously, what if Joanna comes to the party?

(v) ??{Exactly/Roughly} what if we turn on the particle accelerator?

(vi) ??Maybe what if we borrow Alfonso's car?

they involve an ordinary conditional *if*-clause. This rules out, say, treating *what if*s as disguised epistemic possibility claims, as this doesn't account for the fact that the whole *if*-clause is non-idiomatic, including *if* itself.[18]

4 The semantics of *what if*

Let us now move on to the semantics of *what if*. As advertised in Section 2, we will present two closely related treatments of *what if* questions: as conditional questions (CQs) and suppositional questions (SQs). Because the CQ analysis builds and expands on an earlier proposal in Rawlins 2010, we start with a revised version of this proposal before offering the alternative SQ treatment.

4.1 CQ analysis in brief

Our entry point into the semantics of *what if* questions are examples of resistance like this:

(52) A: Is Alfonso coming to the party?
B: Yes.
A: What if Joanna will be there?

Intuitively, A seems to be asking the following conditional question:

(53) If Joanna will be at the party, is Alfonso coming?

So a natural first proposal is that *what if* questions are just a species of conditional question that involve re-asking the current QUD under a supposition contributed by the *if*-clause. Rawlins 2010 implements this proposal in a variant of Isaacs & Rawlins's (2008) dynamic semantics for conditional questions more generally (see Heim 1982, 1983, Veltman 1996, Beaver 2001 for some dynamic semantics classics; see Hulstijn 1997, Velissaratou 2000, Ciardelli, Groenendijk & Roelofsen 2013 for related work on CQs). Where c is a discourse context,

(54) $c + \ulcorner \textit{if } \varphi, \psi? \urcorner = c + \texttt{Assume}(\varphi) + \texttt{Question}(\psi?)$

In broad outline, updating c with the conditional interrogative $\ulcorner \textit{if } \varphi, \psi? \urcorner$ involves the following two steps:

[18] You can think of our goal as an analysis of *whif*, close cousin to regular *if*.

- Temporarily assuming the antecedent φ and thereby entering a new local context $c + \texttt{Assume}(\varphi)$ in which the set of possibilities under consideration is restricted to those in which this antecedent holds (cf. suppositional accounts in Ramsey 1929, Adams 1965, 1975, Mackie 1973, Heim 1983, Edgington 1986, among many others).[19]
- Asking the question expressed by the consequent ψ? in this derived local context.

According to Rawlins, *what if* questions work in much the same way, except that the question posed inside the hypothetical context is a QUD supplied anaphorically by context:

(55) $c + \ulcorner \textit{What if } \varphi? \urcorner = c + \texttt{Assume}(\varphi) + \text{QUD}_c?$

For example, on the conditional question analysis of A's *what if* in (52), this question serves first to assume that Joanna is coming, triggering a local hypothetical context where worlds in which Joanna is not coming are temporarily off the table, and then to re-ask the QUD (*Is Alfonso coming?*) over this restricted domain. This accords with intuition: since this is basically just the update corresponding to (53), the CQ analysis delivers a nice result.

4.2 Formal discourse model

To flesh out both the CQ analysis and the SQ analysis we offer later on, we develop a broadly Stalnakerian model of discourse (Stalnaker 1978, 2002, 2014). In Section 6, we upgrade our model with decision-theoretic structure, but for the time being we want to remain in more familiar territory and work with a representation of context in the style of Roberts 1996 and Farkas & Bruce 2010.

Letting $\mathscr{W}$ be a non-empty set of possible worlds, we first define our discourse contexts as follows:

(56) **Contexts**

A *context* c is a tuple $\langle cs_c, a_c, \wp\mathscr{A}_c, \mathscr{Q}_c \rangle$ where

a. $cs_c \subseteq \mathscr{W}$ is a set of worlds (the *context set*)

b. $a_c \subseteq \mathscr{W}$ is a set of worlds (the *assumption slot*)

[19] This local context can later be exited through a `Clear` operation, as discussed in Section 4.2.

c. $\mathcal{A}_c$ is a stack of propositions (the *assertion stack*)[20]

d. $\mathcal{Q}_c$ is a stack of sets of propositions (the *topic stack*)

For Stalnaker, the context set cs_c includes the possibilities compatible with what is being taken for granted or presupposed for the purposes of the conversation (in its latest incarnation in Stalnaker 2014, cs_c is spelled out using epistemic logic in terms of the higher-order notion of *common acceptance*, though see Lederman 2018b,a for arguments against using higher-order "common" attitudes to explain coordination in discourse). Here we take cs_c to represent fairly stable information in the common ground (not what is being temporarily assumed) — for present purposes, you can think of cs_c as modeling what is publicly believed by the discourse participants.

Instead of building speakers' suppositions directly into the context set itself, we represent them separately using another parameter: the assumption slot a_c (Rawlins 2010 calls this the "view"). This slot serves as a temporary window onto part of the context set — the participants' current view is restricted to the worlds inside $cs_c \cap a_c$ (the default setting is $a_c = \mathcal{W}$ when no assumptions are in force).[21] In this paper, we use the assumption slot to model the local contexts generated in the evaluation of various *indicative* conditional constructions. But this parameter could also be used to model the context change potential of other conditional constructions and related expressions that trigger hypothetical contexts (like *suppose* sentences).[22]

The remaining components of a context c are the assertion stack $\mathcal{A}_c$ and topic stack $\mathcal{Q}_c$ (cf. Farkas & Bruce's 2010 'tables', which generalize the QUD stacks in Roberts 1996). These stacks keep a short history of assertions made by conversational participants, and a short history of questions that are currently under consideration respectively. The assertion stack $\mathcal{A}_c$

[20] We assume some familiarity with stacks; see for example S. Kaufmann 2000 and Isaacs & Rawlins 2008 for similar uses. We use the following (standard) notation: $push(x, s)$ is the stack obtained by adding x to the top of stack s, $pop(s)$ is the stack obtained by removing the top element of s, and $top(s)$ designates the top element.

[21] See Isaacs & Rawlins 2008 for an alternative way of implementing assumptions using stacks of context sets ("macro contexts"). We could have equally well worked in their framework where making an assumption adds a new context set incorporating the assumed content to the top of the macro context.

[22] Although some of our earlier examples like (1) and (2) involve counterfactual suppositions, formally modeling these counterfactual *what if*s would require us to introduce even more discourse structure (similarity orderings, structural equations, or whatnot). So we model only ordinary 'factual' discourse here. That said, while we don't develop a theory of counterfactual *what if*s in all its glory, in footnotes we do suggest ways to adjust our model to handle them.

captures how assertions are *proposals* to update the context set cs_c with their content.[23] In our formal system, asserting a proposition places it in this purgatory where it must wait for either acceptance (i.e., incorporation into the context set) or rejection by the audience.[24] Meanwhile, asking a question places it on the topic stack $\mathcal{Q}_c$. This second stack is loaded up with questions awaiting resolution, each represented as a set of propositions (the questions on the topic stack encode the discourse participants' "strategies of inquiry" as in Roberts 1996).

Without going into details, we assume that question denotations are compositionally constructed as alternative sets in the style of Hamblin 1973 and Kratzer & Shimoyama 2002. Polar interrogatives denote singleton sets (Roberts 1996, Biezma & Rawlins 2012):

$[\![\textit{Is it raining?}]\!] = \{\lambda w_s.\text{raining in } w\}$

Alternative questions are the union of the disjuncts:

$[\![\textit{Is it raining}\uparrow \textit{ or snowing}\downarrow\textit{?}]\!] = \{\lambda w_s.\text{raining in } w, \lambda w_s.\text{snowing in } w\}$

Constituent questions are constructed pointwise based on the domain of the wh-item:

$[\![\textit{What is the weather like?}]\!] = \{\lambda w_s.\text{raining in } w, \lambda w_s.\text{sunny in } w, ...\}$

Moreover, we adopt the following notions of answerhood based on those in Roberts 1996:

(57) **Answerhood conditions**

Given a question Q that is not yet settled in context c because one or more of its members is not yet evaluated in c (i.e., there is some $A \in Q$ such that $cs_c \cap a_c \not\subseteq A$ and $cs_c \cap a_c \not\subseteq \mathcal{W} - A$):

a. P *partially answers* Q in c iff for some alternative $A \in Q$ that is not yet evaluated in c, P contextually entails either A or $\mathcal{W} - A$.

b. P *completely answers* Q in c iff for each alternative $A \in Q$, P contextually entails either A or $\mathcal{W} - A$.

(where P *contextually entails* P' in c iff $P \cap cs_c \cap a_c \subseteq P'$)

[23] Stalnaker 1978 recognizes the proposal nature of assertion but he deemphasizes it, so many working in the Stalnakerian tradition simply assume that assertions automatically update the discourse context unless rejected.

[24] For ease of exposition, we assume that assertions are always proposals to update with their propositional content and ignore cases like epistemic modalized claims where it is unclear that assertors are even expressing propositions (Yalcin 2011). See Bledin & Rawlins 2016 for more discussion and for alternative models of the assertion stack that can handle such cases.

Like Roberts, we require that complete answers to questions higher up on the topic stack $\mathscr{Q}_c$ partially answer questions lower down. This will follow from the dynamics of questioning in our model.

The question at the top of the stack, $top(\mathscr{Q}_c)$, is under immediate discussion and is interpreted through the lens of the current context (we refer to this topmost question as the "current QUD" or sometimes just "QUD" for short). Note that any question Q induces an equivalence relation between possible worlds (or *subject matter*, in the sense of Lewis 1988a,b) where w and v are equivalent iff these worlds are members of the same propositions in Q (a singleton alternative set denoted by a polar interrogative generates a bipartite equivalence relation):[25]

(58) $w \sim_Q v$ iff for each alternative $A \in Q$, $w \in A \equiv v \in A$

We assume here that speakers always want complete answers to their questions, so we identify the QUD *in context* with the set of equivalence classes induced by $top(\mathscr{Q}_c)$ over the context set cs_c visible within a_c (cf. Groenendijk & Stokhof 1984, Groenendijk 1999); that is, the QUD in context is the *quotient set* over the current domain of live options $cs_c \cap a_c$ determined by the equivalence relation $\sim_{top(\mathscr{Q}_c)}$:[26]

(59) **QUD in context**

Where c is a context,

$$\text{QUD}_c = \begin{cases} (cs_c \cap a_c)/\sim_{top(\mathscr{Q}_c)} & \text{if } \mathscr{Q}_c \neq \langle\rangle^{27} \\ \{cs_c \cap a_c\} & \text{otherwise} \end{cases}$$

(60) **Contextual inquisitivity** (after Groenendijk 1999, Rawlins 2010; a.o.)

A context c is *inquisitive* iff $|\text{QUD}_c| > 1$.

[25] While (as both an anonymous reviewer and Josh Dever p.c. suggest) it might be technically simpler to work with a partition from the beginning, we have taken the current approach as a compact but general implementation of Roberts 1996 that allows for a clean integration of alternative sets and contextual domain restriction, without the assumption that the alternative sets generated by the compositional semantics are partitions (Ciardelli, Groenendijk & Roelofsen 2013, Biezma & Rawlins 2012, 2017). Even if $top(\mathscr{Q}_c)$ were a partition already, we would still need a mechanism (on our approach) for doing contextual domain restriction.

[26] We do not worry about *mention-some* readings here. This is not to say that these readings are unimportant; mention-some wh-questions are, for instance, one of the motivations for the recent development of *inquisitive semantics* (Ciardelli, Groenendijk & Roelofsen 2013, 2018). While we think that the main ideas of this paper can be recast in an inquisitive semantics framework, we do not have space to go into details here.

For example, suppose that $\mathscr{W} = \{w_1, w_2, w_3, w_4\}$, where Carlos is having a birthday party in w_1 and w_2, Maggie is having a party in w_1 and w_3, and nobody is having a party in w_4. Suppose also that $cs_c \cap a_c = \mathscr{W}$ and $top(\mathscr{Q}_c) = [\![\textit{Who is having a party?}]\!] = \{\{w_1, w_2\}, \{w_1, w_3\}\}$. Then $\text{QUD}_c = \mathscr{W}/\sim_{top(\mathscr{Q}_c)}$ $= \{\{w_1\}, \{w_2\}, \{w_3\}, \{w_4\}\}$ and the immediate discourse goal of the participants is to locate the world inside one of the cells in this partition (or to at least establish that the world does not lie inside this or that cell). Note that the QUD in context can change as either the context set cs_c or assumption slot a_c changes, even if the topic stack $\mathscr{Q}_c$ remains unchanged. For instance, if the speakers assume that Carlos is having a party, then the QUD in context shifts to $\text{QUD}_{c'} = \{w_1, w_2\}/\sim_{top(\mathscr{Q}_{c'})} = \{\{w_1\}, \{w_2\}\}$.

Turning to the dynamic component of our model, let us first consider an assertion + acceptance sequence.[28] Our assertive update is fairly straightforward: it simply adds the proposition asserted to the assertion stack. An assertion is *relevant* just in case the proposition added to the stack partially answers $top(\mathscr{Q}_c)$ by excluding at least one of the alternatives in QUD_c. Admittedly, this requirement from Roberts 1996 is overly restrictive, as assertions that only shift a speaker's credences over QUD_c without ruling out a cell (Büring 2003, Simons et al. 2010) or that serve only to bring alternatives in QUD_c to one's attention (Franke & de Jager 2010) can also be relevant. But we will not pursue a weaker relevance requirement here.

(61) **Assertive update**

$c + \texttt{Assert}(\varphi) = \langle cs_c, a_c, push([\![\varphi]\!], \mathscr{A}_c), \mathscr{Q}_c \rangle$

Felicity condition: appropriate in c only if
$[\![\varphi]\!] \cap P = \varnothing$ for some $P \in \text{QUD}_c$.

While relevance is necessary for appropriate assertion, it is certainly not sufficient; presumably, one will also want a sincerity condition (Searle 1969) or a stronger epistemic requirement like Williamson's (1996, 2000) rule that we assert only what we know.[29] But since we don't distinguish between public

[27] The quotient set notation $S/\sim$ shouldn't be confused with the set difference notation $S \setminus T$. The former is the set of all equivalence classes in S with respect to the equivalence relation $\sim$ while the latter is the set of all elements in S not in T.

[28] Although assertive/acceptance updates are not needed for the analysis of *what if* questions themselves, these updates will allow us to more fully analyze exchanges in which *what if*s occur.

[29] See Weiner 2005, Lackey 2007, Hill & Schechter 2007, Kvanvig 2009 for criticism of this Knowledge Rule and alternative norms of assertion.

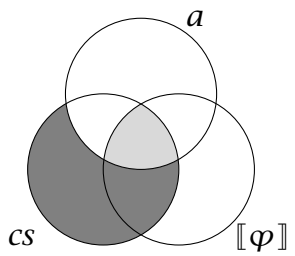
and private information in our model, we do not make this other dimension of felicity explicit.

What happens when an assertion is accepted? As in the original Stalnakerian theory, the asserted content is added to the context set. In our current framework, however, this update takes place only within the window of the current view a_c. Because what a speaker asserts will often depend on the assumptions currently in play — that is, assertions are often conditional on a_c — we take accepted assertions to update only the visible field of the discourse $cs_c \cap a_c$, not the full context set cs_c. To formalize this, we use the following operation (cf. 'support' in S. Kaufmann 2000, 'percolation' in Isaacs & Rawlins 2008):

(62) **Domain-restricted informative update**

$$cs_c \oplus_{a_c} [\![\varphi]\!] = (cs_c \cap a_c \cap [\![\varphi]\!]) \cup (cs_c - a_c).$$

After an update with $[\![\varphi]\!]$ in c, the worlds remaining are those in the visible light grey region $cs_c \cap a_c \cap [\![\varphi]\!]$ together with those in the darker region $cs_c - a_c$ (these latter worlds cannot be eliminated, as they are not even in view). Equivalently, the update serves to kick all and only the not-φ-worlds out of the live field of the discourse $cs_c \cap a_c$.



Acceptance can now be defined in terms of this domain-restricted update. When an assertion is accepted the context is updated with the top element of the assertion stack, which is then removed from the stack:

(63) **Acceptance**

$$c + \texttt{Accept} = \langle cs_c \oplus_{a_c} top(\mathscr{A}_c), a_c, pop(\mathscr{A}_c), \mathscr{Q}_c \rangle$$

Defined only if $\mathscr{A}_c \neq \langle\rangle$.

Felicity condition: appropriate in c only if $cs_c \oplus_{a_c} top(\mathscr{A}_c) \neq \varnothing$.

It is worth noting that in the limiting case where $cs_c \subseteq a_c$, the update (62) amounts to regular intersection: $cs_c \oplus_{a_c} [\![\varphi]\!] = cs_c \cap [\![\varphi]\!]$. So the conversational sequence $c + \texttt{Assert}(\varphi) + \texttt{Accept}$ behaves like an ordinary Stalnakerian assertion move.[30]

[30] Because acceptance is the default response to assertion (as Farkas & Bruce 2010 put it, assertions "project" their acceptance), the acceptance step often happens silently/implicitly.

Moving on to questions, our questioning update is at its core much like the earlier assertive update: it simply places a new question onto the topic stack. But, as before, this added question must be relevant to the current state of the discourse. If there was already a question on the stack, then a complete answer to the new question must partially answer the question that was previously on top (Roberts 1996).[31] Whether there was previously a question on the stack or not, the new question must also render the context inquisitive (in the sense of (60)). This blocks questions that are already settled in the context relative to the suppositions in force. Formally, this is captured by the following update:

(64) **Questioning update**

$c' = c + \texttt{Question}(\varphi?) = \langle cs_c, a_c, \mathscr{A}_c, push([\![\varphi?]\!], \mathscr{Q}_c)\rangle$

Felicity conditions: appropriate in c only if

a. if $\mathscr{Q}_c \neq \langle\rangle$, then each cell in the partition $\text{QUD}_{c'}$ is the union of cells from QUD_c (i.e., for every $P \in \text{QUD}_{c'}$, there are $P', P'', \ldots \in \text{QUD}_c$ such that $P = P' \cup P'' \cup \ldots$) (Relevance)

b. $|\text{QUD}_{c'}| > 1$ (Inquisitivity)

The relevance and inquisitivity conditions are necessary but not jointly sufficient for appropriate questioning. Presumably, a questioner must not already accept one of the answers to her question — though this Searlean "preparatory condition" can be suspended in exam contexts and other non-standard situations — and she must also think that the addressees can potentially help to resolve the question.

Let us put just a few more pieces into place. To deal with conditional constructions, we still need a dynamic update to capture the effects of *if*-clauses. In our formal system, these clauses intersectively update the assumption slot with their content and thereby restrict the speakers' window onto the context set (S. Kaufmann 2000, Isaacs & Rawlins 2008):[32]

But sometimes acceptance is explicitly marked by particles like *Okay*, *Sure*, etc., or signaled by nodding and other physical gestures.

[31] We actually impose a stronger constraint where the added question must be a *subquestion* of the question previously on top in the sense that any complete answer to the old question is a complete answer to the new question.

[32] Though we are not trying to model counterfactual discourse in this paper, one might worry at this point about the prospects of extending our formal system in this direction given the definability condition for `Assume` in (65). If intersecting with the proposition expressed by a counterfactual *if*-clause results in the empty set, then the system crashes.

(65) **Assuming**

$c + \texttt{Assume}(\varphi) = \langle cs_c, a_c \cap [\![\varphi]\!], \mathscr{A}_c, \mathscr{Q}_c \rangle$

Defined only if $cs_c \cap a_c \cap [\![\varphi]\!] \neq \emptyset$.

In the other direction, the following utility update resets the assumption slot:

(66) **Clear**

$c + \texttt{Clear} = \langle cs_c, \mathscr{W}, \mathscr{A}_c, \mathscr{Q}_c \rangle$

Defined only if $a_c \neq \mathscr{W}$.

We also want some more ways to dial back the table. Right now, the only way to pop the assertion stack is through acceptance. However, not all assertions are accepted, so a complete system must also allow for `Retraction` and perhaps also `Agreement to Disagree` (see Farkas & Bruce 2010 and Bledin & Rawlins 2016 for implementations; we will not require these moves here). The topic stack can also be popped with the following utility update:

(67) **Dispel**

$c + \texttt{Dispel} = \langle cs_c, a_c, \mathscr{A}_c, pop(\mathscr{Q}_c) \rangle$

Defined only if $\mathscr{Q}_c \neq \langle\rangle$.

We regard `Clear` and `Dispel` as discourse maintenance operations needed to keep track of the changing attitudes and goals of the participants. Unlike our other updates, they are not triggered by specific linguistic constructions. When needed, the need for a `Clear` or `Dispel` operation must still

However, we see this as a potentially useful design feature rather than a bug. In his work on counterfactuals (CFs), von Fintel 2001 argues that CFs can be analyzed as strict conditionals that quantify over a "modal horizon" that can widen as discourse proceeds (Gillies 2007 also analyzes CFs along these lines). Something like this contextual parameter could help us deal with counterfactual *what if*s. Suppose, following von Fintel, that in addition to the context set cs_c, each context c comes equipped with an "accessibility function" f_c mapping worlds in $\mathscr{W}$ to sets of worlds, with the default setting $f_c(w) = \{w\}$. We can then take the counterfactual domain to be $f^{cs_c} = \bigcup_{w \in cs_c} f_c(w)$, which collects all of the worlds obtained by applying f_c to each world w in cs_c (we have as the default that $f^{cs_c} = cs_c$). Now the fix: let `Assume` be defined only if $f^{cs_c} \cap a_c \cap [\![\varphi]\!] \neq \emptyset$ and allow for repair when this condition is violated by expanding the domain f^{cs} beyond the context set (see von Fintel for details on how this might be implemented using similarity orders). The revised definability condition would be similar to Heim's compatibility presupposition for CFs reported by von Fintel (what Gillies calls an "entertainability presupposition"), but there is nothing distinctively counterfactual about it — as part of `Assume`, it would also apply to indicative conditionals.

be inferred from what is being said. When speakers stop using modal subordination morphology on their responses (e.g., *would*; Roberts 1989), this can signal that they have departed a local context via `Clear`. When speakers' assertions/acceptance leave the discourse in an uninquisitive state where $|\text{QUD}_c| = 1$ (i.e., the QUD, if any, has been resolved with respect to the live possibilities $cs_c \cap a_c$), we take it that this will typically trigger an adjustment of the context by `Clear`, `Dispel`, or both, so that inquisitivity is restored.

4.3 Example

Before turning to the formal CQ analysis of *what if* questions, it will be instructive to walk through a quick example to get more of a feel for how our machinery works. So consider $\mathscr{W} = \{w_1, w_2, w_3, w_4\}$, where Alfonso is coming to the party in w_1 and w_2 only, Joanna is coming in w_1 and w_3 only, and nobody else matters.

(68) A: Who's coming to the party?
B: If Joanna is coming, Alfonso is not.
A: OK. Well, is Joanna coming?
B: Yes.

Initially, $c_0 = \langle \mathscr{W}, \mathscr{W}, \langle\rangle, \langle\rangle\rangle$. Assuming that the quantificational domain of A's lead-off question is restricted to Alfonso and Joanna (Grewendorf 1981), the context shifts to

$$\begin{aligned} c_1 &= c_0 + \texttt{Question}(\textit{Who's coming?}) \\ &= \langle \mathscr{W}, \mathscr{W}, \langle\rangle, \langle\{\{w_1, w_2\}, \{w_1, w_3\}\}\rangle\rangle \end{aligned}$$

where $\text{QUD}_{c_1} = \{\{w_1\}, \{w_2\}, \{w_3\}, \{w_4\}\}$. B's conditional reply then triggers a hypothetical context where only worlds in which Joanna is coming are in view and the proposition that Alfonso isn't coming is placed in purgatory. Note that this proposition completely answers the QUD within the subordinate context (since $\text{QUD}_{c_2} = \{\{w_1\}, \{w_3\}\}$):

$$\begin{aligned} c_2 &= c_1 + \textit{If Joanna is coming, Alfonso isn't coming} \\ &= c_1 + \texttt{Assume}(\textit{Joanna is coming}) + \texttt{Assert}(\textit{Alfonso isn't coming}) \\ &= \langle \mathscr{W}, \{w_1, w_3\}, \langle\{w_3, w_4\}\rangle, \langle\{\{w_1, w_2\}, \{w_1, w_3\}\}\rangle\rangle \end{aligned}$$

A's "OK" response signals acceptance, and so the update $\oplus_{\{w_1, w_3\}}\{w_3, w_4\}$ removes the world w_1 in which both Alfonso and Joanna are coming from the context set:

$$\begin{aligned} c_3 &= c_2 + \texttt{Accept} \\ &= \langle \{w_2, w_3, w_4\}, \{w_1, w_3\}, \langle\rangle, \langle \{\{w_1, w_2\}, \{w_1, w_3\}\}\rangle\rangle \end{aligned}$$

At this point, $\mathrm{QUD}_{c_3} = \{\{w_3\}\}$ so things are no longer inquisitive. But a `Clear` update takes us back to the main categorical context of the discourse, which *is* inquisitive:

$$\begin{aligned} c_4 &= c_3 + \texttt{Clear} \\ &= \langle \{w_2, w_3, w_4\}, \mathscr{W}, \langle\rangle, \langle \{\{w_1, w_2\}, \{w_1, w_3\}\}\rangle\rangle \end{aligned}$$

Note that without this `Clear`, A's follow-up polar interrogative (which adds another question to the topic stack) would be infelicitious:

$$\begin{aligned} c_5 &= c_4 + \texttt{Question}(\textit{Is Joanna coming?}) \\ &= \langle \{w_2, w_3, w_4\}, \mathscr{W}, \langle\rangle, \langle \{\{w_1, w_3\}\}, \{\{w_1, w_2\}, \{w_1, w_3\}\}\rangle\rangle \end{aligned}$$

B's subsequent answer now adds the proposition that Joanna is coming to the assertion stack:

$$\begin{aligned} c_6 &= c_5 + \texttt{Assert}(\textit{Joanna is coming}) \\ &= \langle \{w_2, w_3, w_4\}, \mathscr{W}, \langle \{w_1, w_3\}\rangle, \langle \{\{w_1, w_3\}\}, \{\{w_1, w_2\}, \{w_1, w_3\}\}\rangle\rangle \end{aligned}$$

Assuming that A silently accepts B's response, this proposition is then incorporated into the context set:

$$\begin{aligned} c_7 &= c_6 + \texttt{Accept} \\ &= \langle \{w_3\}, \mathscr{W}, \langle\rangle, \langle \{\{w_1, w_3\}\}, \{\{w_1, w_2\}, \{w_1, w_3\}\}\rangle\rangle \end{aligned}$$

Finally, with the issues on the topic stack completely resolved, a series of `Dispel` updates removes them from the stack:

$$\begin{aligned} c_8 &= c_7 + \texttt{Dispel} + \texttt{Dispel} \\ &= \langle \{w_3\}, \mathscr{W}, \langle\rangle, \langle\rangle\rangle \end{aligned}$$

In the end, the assumption slot is clear, the table is empty, and the context set has been reduced to the maximally informed context set $\{w_3\}$ containing only the world where Joanna is coming to the party but Alfonso is not.

4.4 *What if*s as conditional questions

We have just seen an example of conditional assertion. Schematically, this takes the following form:

(69) $c + \ulcorner \textit{if } \varphi, \psi \urcorner = c + \texttt{Assume}(\varphi) + \texttt{Assert}(\psi)$

Updating with $\ulcorner \textit{if } \varphi, \psi \urcorner$ amounts to first assuming φ and then asserting ψ over the temporarily restricted domain. Importantly, the assumption constrains the effect of the subsequent assertion should ψ move from the table to the context set via acceptance.[33]

A conditional question update works in much the same way. The only difference is that the post-assumption move is now asking rather than asserting:

(70) $c + \ulcorner \textit{if } \varphi, \psi? \urcorner = c + \texttt{Assume}(\varphi) + \texttt{Question}(\psi?)$

There is still significant interaction between the subcomponents of this update: the initial assumption step delimits the QUD induced by the question $[\![\psi?]\!]$ expressed by the consequent, as the discourse participants will try to resolve this question relative only to the temporarily restricted domain.

As for *what if* questions, these can now be treated as conditional questions where the question component is re-asking the current QUD:

(71) ***What if* update, CQ version**

$$\begin{aligned} c + \ulcorner \textit{What if } \varphi? \urcorner &= c + \texttt{Assume}(\varphi) + \mathrm{QUD}_c? \\ &= \langle cs_c, a_c \cap [\![\varphi]\!], \mathscr{A}_c, \mathscr{Q}_c \rangle + \mathrm{QUD}_c? \\ &= \langle cs_c, a_c \cap [\![\varphi]\!], \mathscr{A}_c, \mathit{push}(\mathit{top}(\mathscr{Q}_c), \mathscr{Q}_c) \rangle \end{aligned}$$

In our earlier example from Section 4.1, repeated below as (72), A's *what if* question serves to first intersect the current assumption slot a_c with the proposition $[\![\textit{Joanna is coming}]\!]$ and then re-ask the QUD by re-adding $[\![\textit{Is Alfonso coming?}]\!]$ to the topic stack (crucially, A's resistance move indicates that she isn't yet willing to accept B's answer by moving the proposition $[\![\textit{Alfonso is coming}]\!]$ from the assertion stack into the context set, and so the inquisitivity condition is satisfied):

(72) A: Is Alfonso coming to the party?
B: Yes.
A: What if Joanna is coming?

[33] Note that $c + \texttt{Assume}(\varphi) + \texttt{Assert}(\psi) + \texttt{Accept} + \texttt{Clear}$ is effectively Heim's (1983) classic dynamic entry for conditionals. On our theory, the latter `Accept` and `Clear` operations are not part of the semantic clause for *if* but are rather updates that occur if the speaker's (conditional) assertion using ψ is accepted in the local context in which φ is being assumed and the interlocutors then exit this local context.

(73) c + *What if Joanna is coming?*
$= c$ + Assume(*Joanna is coming*) + QUD_c?
$= c$ + Assume(*Joanna is coming*) + Question(*Is Alfonso coming?*)
$= \langle cs_c, a_c \cap [\![\textit{J. is coming}]\!], \mathscr{A}_c, \textit{push}([\![\textit{Is A. coming?}]\!], mathcalQ_c)\rangle$

Following A's challenge, the immediate discourse goal is to determine whether Alfonso is coming to the party given the assumption that Joanna will be there.

4.5 *What if*s as suppositional questions

The CQ analysis seems to work well for the *what if* "resistance move" in (72). It captures how A is resisting B's proposed answer to the QUD by re-posing this question over the restricted domain where the issue of whether Joanna is coming is settled in the affirmative — an issue that A thinks B might be overlooking.[34]

However, one might worry that the CQ analysis delivers the right end result but still gets the mechanism wrong. After all, do we really need the questioning part of the conditional question? Note that in (73) the second update $+\text{QUD}_c$? is redundant within our formal system because it functions only to place a duplicate inert copy of [[*Is Alfonso coming?*]] onto the topic stack. Because the relevance condition of the questioning update (64) allows for the case where $\text{QUD}_c = \text{QUD}_{c'}$, this update does not itself block questioning that fails to bring any new alternatives into play (at least when the topic stack is non-empty). But one might want to ban or restrict such trivial updating in a more refined model of discourse.

This is partly a technical theory-internal worry, but it also has an empirical component. Full CQ responses that literally repeat a previous question tend to sound quite odd, and typically require some alternate phrasing or subjunctive marking:

(74) A: Are you going to the party?
B: No.
A: ??Are you going to the party if Joanna is there?
A′: Would you {go/change your mind} if Joanna is there?

[34] See Bledin & Rawlins 2016 for further discussion of resistance moves. In this complementary research, we propose that resistance moves can be used to draw a hearer's attention to new subject matters and potentially lead them to reevaluate their commitments. While the attentional effects of *what if*s are clearly important, we do not explicitly model them here.

While CQ re-asking responses might be acceptable in certain contexts where they provide needed emphasis, they are not generally felicitous across the board, presumably because their questioning component fails to move the discourse forward in any way (see Crone 2017 for related exploration of when 'redundant' utterances are licensed in discourse). The empirical worry is that if we treat *what if*s as CQs, it is not clear why they pattern differently from full CQs, like A's re-asking response in (74), with respect to felicity.

At this point, we can introduce a second version of our analysis that retains the basic idea that *what if*s are conditional-question-like, as well as the observation that it is really only the *if*-clauses of *what if*s that are compositional, but avoids the redundancy worry with the CQ analysis. On the new proposal, *what if* questions are *suppositional questions* that, like CQs, generate local contexts in which their *if*-clauses are assumed to hold, but, unlike CQs, do not involve any actual questioning themselves. While the earlier CQ entry for *what if* involved both assumption and questioning updates, our new stripped-down entry has only the former assumption step:

(75) ***What if* update, SQ version**

$c' = c + \ulcorner \textit{What if } \varphi? \urcorner = c + \texttt{Assume}(\varphi)$

Felicity condition: appropriate in c only if
$|\text{QUD}_{c'}| > 1$ (Inquisitivity)

Note that the connection to questions has not been completely severed. While the questioning update $+\text{QUD}_c?$ in (71) is gone, we have retained the inquisitivity condition familiar from questioning in general, which now requires that the posterior context c' be inquisitive: after updating with $+\texttt{Assume}(\varphi)$, $\text{QUD}_{c'}$ must partition $cs_{c'} \cap a_{c'}$ into multiple cells. This ensures that there is a live question to be resolved in the temporary local context created by the *what if*.[35]

As on the CQ analysis, we can still say that *what if*s serve to re-pose (or transpose) questions under the suppositions contributed by their *if*-clauses. But whereas both suppositional and questioning updates were hardwired into the original CQ update (71), only the suppositional update now remains. On the more minimal SQ update (75), the sole conventional discourse effect of *what if* is to introduce an assumption, which serves — when *what if* is felicitous — to re-pose an already existing question over a more restricted

[35]This post-update inquisitivity test broadly resembles the *post-suppositions* of Brasoveanu 2013, Henderson 2014.

contextual domain (technically there is no re-asking). Any new questioning must be a secondary pragmatic effect coming by way of the accompanying felicity condition requiring that the discourse context be inquisitive after the assumption slot has been narrowed (much more on this still to come).[36]

4.6 A non-inquisitive *suppose* story?

Because the CQ and SQ versions of our proposal are so closely related and the differences between them will not matter for the issues we want to take up in the remainder of the paper, we will not try to further motivate the SQ analysis over its CQ rival. If you aren't worried about redundancy and want to hold on to the idea that *what if*s explicitly ask questions, then feel free to stick with the CQ analysis.

We do, however, want to reject a third candidate analysis of *what if* constructions. Given that we have already suggested weakening the question-hood component of *what if*s in the proposed move from the CQ to the SQ analysis, one might want to do away with question-hood altogether and assimilate *what if*s to suppositional imperatives (Isaacs 2007). On the *non-inquisitive* story we have in mind, *what if*s have only the assumption step but no inquisitivity requirement (though they still have whatever felicity conditions govern supposing).[37]

A proponent of such a *suppose*-style account might argue that it is only because we have been theorizing about challenging uses of *what if*s that conditional-question-style analyses seem so attractive. Start theorizing from the perspective of suggestive uses and a non-inquisitive analysis seems equally if not more promising. Recall for instance the following example from Section 2 where *what if* is used to suggest a course of action in response to a planning question:

(76) A: How can we get to the party on time?
B: What if you finally stop worrying about damaging your new Ferrari and drive?
B′: Suppose you drive the new Ferrari.

[36] For related discussion of conventional vs. secondary pragmatic discourse effects, see Condoravdi & Lauer 2012, Farkas & Roelofsen 2017.

[37] We are grateful to Josh Dever (p.c.) for pressing us to give this non-inquisitive *suppose* account more consideration.

In this exchange, the main point of B's *what if* response is not really to pose a question in the subordinate context where it is assumed that A stops worrying and drives, but rather to foreground the possibility of him driving. The *what if* response does this by intersecting the assumption slot with the proposition that A drives his Ferrari to the party, and this could equally be achieved using an ordinary *suppose* sentence. It doesn't seem to matter at all whether the resulting local context is inquisitive.

Now, *what if* constructions certainly have empirical properties of suppositions, as we should expect on any of the three analyses offered so far. Their suppositional nature can be seen from their licensing of modal subordination morphology, like *would*, on subsequent responses, similar to regular modal subordination (Roberts 1989) and to modal subordination triggered by conditionals (Roberts 1989, S. Kaufmann 2000, Isaacs & Rawlins 2008):

(77) A: What if a thief breaks in?
B: He *would* steal the silver.

The suppositional nature of *what if*s can also be seen, of course, from the intuition that direct responses only target cases where the content of the *if*-clause holds, but do not in general prejudge whether this content holds (Rawlins 2010).

On the other hand, *what if*s have interrogative morphology and other empirical aspects of questioning as well. One argument for question-hood comes from a diagnostic in Sadock 1974. Sadock notes that the prefix *tell me* works with questions but not assertions. It also works with *what if*s but not *suppose* sentences:[38]

(78) Tell me, {does John own a car?/#John owns a car.} (Reese 2007: ch. 3 ex. 12)

(79) Tell me, {what if Joanna is there?/#suppose Joanna is there.}

In dialogues, *what if*s also act like questions in terms of turn-taking and response-hood. When one asks *what if...?* to a hearer in the course of ordinary discourse, there is the usual expectation that the hearer will answer. In contrast, regular supposition-introducing moves, such as suppositional imperatives and modal utterances intended to trigger modal subordination, are

[38]Interestingly, a related diagnostic from Sadock involving the parenthetical *by any chance* does not seem to work with *what if*s. This diagnostic has been described as selecting specifically for *epistemically neutral* questions; see Reese 2007 for further discussion.

often infelicitous, or at least very awkward, if used to try to get an answer.[39] Compare:

(80) A: What if Napolean had won at Waterloo?
(A looks expectantly at B)
B: We'd all be speaking French.

(81) A: Suppose Napolean had won at Waterloo.
(A looks expectantly at B)
B: (after a long pause) Well? Where are you going with this?

Although A's lead-off utterances in (80) and (81) both introduce the same assumption — that Napolean won at Waterloo — the hypothetical *what if* calls for an answer in a way that the *suppose* directive does not. This observation that *what if*s invite hearers to answer cross-cuts all four uses discussed earlier in this paper (though it should be noted that in monologues and written text, questions can be self-addressed, and at least hypothetical, elaborative, and suggestive *what if*s can be used in this way). Even in (76), where B's *what if* has an attention-targeted rhetorical flavor, A *can* provide an answer if he has something to say about what would happen if he drives to the party that matters for their common goal of making it on time:

(82) B: What if you finally stop worrying...?
A: We'll get stuck in traffic and be late.

This is unsurprising if B's *what if* is a rhetorical CQ or SQ, as regular rhetorical questions, unlike statements and suppose directives, readily allow answers (Caponigro & Sprouse 2007).

We conclude that *what if*s have both suppositional and questioning components. While we leave it open whether the best way to capture this is by treating *what if*s as CQs or SQs, we insist on maintaining some connection to questioning and so reject the proposal to do away with the post-suppositional inquisitivity requirement altogether. In fact, when we turn to the full functional spectrum of *what if* questions, this requirement will play a crucial role in getting good results.

[39] This is not to say that *suppose* and *might* utterances can never be used to implicitly raise questions.

5 QUD accommodation

Let us pause and take stock. Motivated primarily by challenging uses of *what if* that contextually restrict an explicit QUD from preceding discourse, we first presented a conditional question analysis of *what if*s that expands and improves on the earlier analysis of Rawlins 2010. We then offered a new suppositional question analysis with a weaker questioning component, but rejected a non-inquisitive *suppose* account that breaks the tie to questioning altogether. Both of our proposals can account for the challenging and elaborative "re-asking" uses that Rawlins 2010 dealt with in a similar but cleaner way, so if our explananda were only these re-asking cases, we would arguably be finished our project. The CQ and SQ analyses of *what if* nicely explain examples like (72) where the *what if* questioner is continuing a preexisting line of inquiry introduced by a prior question in discourse.

Things get trickier, however, when we turn to the many other cases of *what if*, such as hypothetical and suggestive uses, because it isn't clear that either the CQ or SQ account generalizes. Given that many hypothetical, suggestive, and even some challenging and elaborative *what if*s seem to involve non-trivial questioning that doesn't simply amount to transposing the current QUD into a more limited domain, we need to say more about these other cases. In the remainder of this section, we suggest the beginnings of a story for some examples involving *QUD accommodation*. In the rest of the paper, we then use this idea to bootstrap an analysis involving accommodation of and coordination on shared discourse and domain goals, where the former are analyzed as QUDs and the latter as *decision problems* (van Rooy 2003b; a.o.).

The first kind of challenge comes from cases where there is (arguably) no explicit or implicit QUD available for re-posing, as in hypothetical cases. Here are some additional examples from XKCD:

(83) What if you released a submarine into Jupiter's atmosphere? Would it eventually reach a point where it would float? Could it navigate?

(84) What if we were to dump all the tea in the world into the Great Lakes? How strong, compared to a regular cup of tea, would the lake tea be?

(85) What if everything was antimatter except Earth?

If, as it appears, such discourse-initial *what if* questions are asked when there is no open QUD already in place (i.e., when $\mathscr{Q}_c = \langle\rangle$), then we have a problem. If the hypothetical *what if*s in these examples are interpreted as CQs, there

is nothing for the $+\text{QUD}_c$? update in (71) to grab hold of. If interpreted as SQs, then the inquisitivity condition in (75) is violated.[40]

The second kind of challenge for the CQ and SQ analyses comes from cases where there *is* an open QUD available for re-asking or re-posing, but the *what if* question seems to pose a different question in the local context generated by its *if*-clause. Many suggestive uses are like this, as we have already seen in (76), where B does not seem to be asking how they are going to get to the party on time if A drives his Ferrari. Consider also this variant of the colloquium example from Section 2:

(86) A: Who are we going to invite to speak at the next colloquium?
B: What if we invite Professor Plum?

Informally, the challenge is that B does not seem to be asking who they will invite if they invite Professor Plum. Formally, the problem is that a direct application of either our current CQ or SQ update (not to mention the Rawlins 2010 analysis) crashes. The denotation of A's opening question is:

(87) $[\![\text{Who are we going to invite to the next colloquium?}]\!] =$
$$\left\{ \begin{array}{l} \lambda w_s.\text{we invite Professor Plum in } w, \\ \lambda w_s.\text{we invite Professor McGonagall in } w, \\ \lambda w_s.\text{we invite Professor Xavier in } w, \ldots \end{array} \right\}$$

If this topic determines the current QUD in context and we intersect the assumption slot with the proposition $\lambda w_s.$(we invite Prof. Plum in w) (and then perhaps re-ask the current QUD), then the resulting context is uninquisitive (assuming that the context set excludes the possibility of inviting multiple speakers).

So what should we say about all these troubling examples? Our basic solution is to appeal to QUD accommodation (Lewis 1979; see Cooper & Larsson 2010 for discussion of QUD accommodation in particular).[41] In both kinds of cases that create difficulties for the CQ and SQ analyses, we suggest that the *what if* questions can trigger a repair mechanism whereby hearers will

[40] As a brief aside, it is worth noting that, as an empirical matter, such open-ended, wildly speculative hypothetical *what if* questions are not always appropriate. Despite their apparent discourse-initiality, the context must already be open to talk about far-fetched scenarios. That is to say, examples like (83)–(85) require a context that licenses considerations of strange alternatives — something typically not met in practice. But, of course, the XKCD site provides exactly this sort of context. So the question remains: how can we account for the felicity of these questions?

[41] See also the *China* example (47) in Roberts 2012b where a superquestion of the current QUD is accommodated to satisfy focally-contributed presuppositions.

push a new implicit question onto the topic stack $\mathscr{Q}_c$ to ensure that the post-suppositional context is inquisitive, or that there is even a QUD available for re-asking in the QUD-less cases that pose a more immediate problem for the CQ story. The devil, of course, is in the details. The appeal to QUD accommodation raises the puzzle of which questions are accommodated in particular examples and why these questions are used to repair the discourse context rather than others.[42]

Reflecting first on XKCD-type examples, a natural first suggestion is that hearers will accommodate with the "Big Question" (Roberts 1996) that asks what things are/would be like in every respect. Formally, the Big Question can be modeled with the power set $\mathscr{P}(\mathscr{W})$, which induces the finest possible partitioning of $cs_c \cap a_c$ into singleton sets; that is, after the repair, $\text{QUD}_c = \{\{w\} : w \in cs_c \cap a_c\}$.

Note that accommodating with the Big Question would leave things very unconstrained: any assertion that eliminates any world in $cs_c \cap a_c$ is relevant to it. But before worrying too much about this, note that — as exemplified by the XKCD examples (83) and (84) — many hypothetical *what if* questions are immediately followed by coarser-grained questions that significantly sharpen the focus of downstream inquiry. Take (83), for instance. If hearers accommodate with the Big Question, then the open QUD following the initial *what if* question is the very general question of what things would be like if you released a submarine into Jupiter's atmosphere. There are, of course, plenty of appropriate responses to this. After the two subsequent polar questions, however, only responses that bear on whether the submarine could float and navigate in Jupiter's atmosphere are relevant.

In any case, we are somewhat skeptical that hearers will ever really accommodate with the fully open Big Question.[43] When hypothetical and other

[42]It is worth mentioning that *what about if* questions cannot be accommodated in the same fashion as hypothetical and elaborative *what if*s:

(i) *What about if I entered the atmosphere in my VW Jetta?

(ii) A: Alfonso's coming to the party.
B: ??Uh oh, what about if Joanna is there?

It seems to be something about the *what if* idiom that permits accommodation or something about *what about if* that precludes it. We leave the explanation for this difference as an open problem.

[43]In fact, when it comes to examples like (83) and (84) where a *what if* question heads a sequence in which follow-up questions immediately whittle down the space of inquiry, one might reasonably wonder whether accommodation is even necessary at all. Plausibly, hearers

what if questions force accommodation with new QUDs, these will arguably always be coarsenings of the Big Question. Usually, but not necessarily, the alternatives introduced via accommodation will be *historical alternatives* anchored at the time of the *if*-clause (in the sense of Kaufmann & Schwager 2011). The implicitly raised QUD might also depend on what the interlocutors are *publicly attending* to (in the sense of Bledin & Rawlins 2016), on what hearers can reasonably be expected to know things about, and on any transparent, contextually manifestable goals, plans, and interests of the *what if* questioner. In our colloquium example (86), for instance, we suggest that B's *what if* question forces accommodation not with the fully open Big Question, but with the issue of what things will be like in respects that bear on whether inviting Professor Plum best achieves the speakers' common goals for the talk series. Suppose that the speakers definitely want to invite Professor Plum if he will give a semantics talk, they do not want to invite him if he will give a phonology talk (as the previous two talks in the series were by phonologists), and it isn't yet common ground what kind of talk Plum would give. Then the accommodated question is presumably *whether Professor Plum gives semantics or phonology talks* and this issue *is* open even on the assumption that Plum is invited.

At this point, we are relying on QUD accommodation without much discussion of how such an accommodation process might be constrained, and much of the explanatory power of our account rests on understanding such constraints. To address this concern, we spend the remainder of this paper developing a more careful, detailed account of how QUDs can be constructed in practical, action-directed exchanges like (86) from the real-world domain goals and plans of the speakers. To be clear, QUD accommodation is a very complex phenomenon and we are certainly not going to try to explain how this kind of repair works in all cases in which *what if*s trigger it — to repeat, we restrict our attention in what follows to a range of practical contexts. Nor are we even looking to give a comprehensive account of the repair in (86) and related practical cases; though the discourse moves in our formal system from Section 4 might suggest otherwise, it is far from clear that the complete dynamics of repair in such examples lends itself to a compact systematization in terms of general principles. Our more limited aim in what follows is just to put one particular dimension of the process of QUD accommodation into the formal spotlight by developing a working theory of how new questions introduced in discourse are often constrained by the underly-

do not need to accommodate in such question sequences because the speaker herself quickly corrects the context by asking more questions that render it inquisitive.

ing domain goals in play (like the goal of arranging a successful colloquium) and how this relevance constraint provides one mechanism by which speakers coordinate on QUDs in a range of contexts.

Because QUD accommodation isn't specific to *what if* constructions, the remainder of the paper has reach beyond *what if*. The theory that we develop can be carried over to more standard question constructions that trigger the same kind of repair mechanism. Consider the following example (from Josh Dever p.c.):

(88) A: Who are we going to invite to speak at the next colloquium?
B: Should we invite Professor Plum?
C: He'll give a phonology talk.
A: That would be our third one in a row.

Here, too, C's response seems to call for the conversational relevance of the question *Will Professor Plum give a semantics or phonology talk?*, as in the original *what if* version (86). While our theory in the next few sections is meant to provide an important piece of the final story about the full spectrum of *what if*s, it also presents part of a solution to the more general problem of question accommodation, which pertains to non-*what if* questions like B's *should* question in (88) as well.

6 Bringing in decision problems

Our proposal about QUD accommodation in practical contexts will take a bit of setting up. In this section, we first review how speakers' domain goals can be explicated using *decision problems* (DPs) and show how these DPs can be embedded into a broader "conversational scoreboard" (to borrow Lewis's (1979) metaphor) that extends our formal discourse model from Section 4. We then define a "Subservience" constraint between new questions and the active DPs in a context. The payoff comes only later in Section 7 and Section 8 when we take another look at our colloquium example (86) and also consider a challenging use of *what if* that similarly forces accommodation with a new QUD shaped by the speaker's goals and interests. With Subservience to wield, we will be in a better position to predict the repair in such cases.

6.1 Decision problems

Up to now, we have focused on only a single kind of discourse goal: the goal of publicly resolving a QUD by adding one of its answers to the con-

text set. But besides these goals of inquiry, interlocutors often have various non-discursive domain goals that they hope to achieve in the world, such as finding a newspaper, making it to a party on time, or arranging a successful speaker series. These discourse and domain goals are not independent — the domain goals or plans of a group of interlocutors will generally dictate the questions they take up because, as Roberts 2012b recognizes, "we are, naturally, most likely to inquire first about those matters that directly concern the achievement of our domain goals" (p. 7).

To integrate domain goals into our model of context, let us now bring in some ideas from decision theory. It has become increasingly popular for linguists to appeal to *decision problems* when the natural language phenomenon that they are investigating is sensitive in some way to the real-world domain plans and interests of speakers (for some applications, see van Rooy 2003b on questions, Davis 2009 on Japanese discourse particles, Franke & de Jager 2010 on awareness, M. Kaufmann 2012 on imperatives, Malamud 2012 on plural definites, and Cariani, Kaufmann & Kaufmann 2013 on deliberative modals). DPs encode an agent's preferences — partly in the form of a utility function — over a set of relevant outcomes that can obtain if the agent acts in certain ways and certain states of the world prevail. Note that this is precisely the kind of underlying information that B's suggestive *what if* in (86) seems to target: if A and B decide to take the collective action of inviting Professor Plum to speak at their colloquium, then what will things be like in respects that they care about?

For present purposes, it will be helpful to work with a somewhat non-standard, purely qualitative formulation of DPs:

(89) **Decision problems**

A *decision problem DP* is a tuple $\langle A, S, U \rangle$ where

a. $A \subseteq \mathscr{P}(\mathscr{W})$ is a partition of a subset of $\mathscr{W}$ (the *action set*)

b. $S \subseteq \mathscr{P}(\mathscr{W})$ is a partition of a subset of $\mathscr{W}$ (the *state space*)[44]

c. $U : A \times S \to \mathbb{R}$ is a *utility function*

d. **Orthogonality condition:** A *DP* is *well-formed* iff for each $a \in A$ and $s \in S$, $a \cap s \neq \varnothing$ (i.e., A and S are pairwise compatible or "orthogonal" in the sense of Lewis 1988a).

Unlike in typical multi-sortal presentations, we take both actions and states to be propositions (see Lewis 1981, Jeffrey 1983 for approaches along these

[44]We do not require that the actions in A or states in S cover all of $\mathscr{W}$.

lines). The action set A specifies the alternative options available to the decision maker, who can act at will to realize any of the propositions in the set. In contrast, which state in S obtains is assumed to be outside the agent's control. We take it that each action-state pair $\langle a, s\rangle$ determines a particular outcome that the decision maker cares about, like making it to a party on time, being late to a party, hosting a successful colloquium, hosting a boring and ill-attended colloquium, and so forth. This outcome holds throughout the set of worlds $a \cap s$ which are nonempty so long as DP is well-formed.[45]

Which action the agent performs will depend on the preferences she has over the achievable outcomes and on how she goes about making decisions. Her preferences are encoded in the utility function U, where $U(a, s) \leq U(a', s')$ just in case the possible worlds in $a' \cap s'$ are at least as preferred as those in $a \cap s$.[46] We work with only ordinal properties of an agent's preferences in this paper. While a utility function can also encode the relative strength or intensity of preferences, we do not require such additional information in what follows.

Together with acts, states, and utilities, DPs used to model decisions *under risk* (as opposed to those *under strict uncertainty*) also typically include a probability measure Pr over the state space S that represents the agent's degrees of belief or *credences* in these exogenous states. With both probabilities and cardinal utilities to draw on, rational decision makers can then be regarded as *expected utility maximizers* who will refrain from performing any action in A whose expected utility across the state space is less than some alternative action. However, we are looking to bring in neither probabilities nor the methods of statistical decision theory (unlike van Rooy 2003b,a, Franke & de Jager 2010, who put these to good use). So we will continue to qualitatively represent the shared public beliefs of a group of speakers using a Stalnakerian context set, a separate component of the discourse context. We also assume that speakers facing DPs in practical deliberative contexts want to get rid of any uncertainty they have about what to do by reaching a future discourse context where their problem is *resolved* in the sense that one of their potential actions has optimal consequences in every state that remains open (more on this in the next section).

[45] The orthogonality condition is meant to capture the requirement of Savage 1954 that the acts and states used in framing DPs be independent of each other.

[46] For readers familiar with Condoravdi & Lauer 2012: the set of propositions $\{a \cap s : a \in A, s \in S\}$ with ordering $a \cap s \leq a' \cap s'$ iff $U(a, s) \leq U(a', s')$ is a "preference structure" (we could have taken this ordering as basic).

Despite these differences, domain goals can still be modeled in a fairly typical fashion. For a stock example, suppose I am looking to purchase an Italian newspaper and I consider whether to walk to the station or to the palace to buy one (Groenendijk & Stokhof 1984, van Rooy 2003a). Assuming that all I care about is getting my hands on a paper and avoiding unnecessary movement, my goal can be represented as follows:

(90)
$$A = \left\{ \begin{array}{l} \lambda w_s.\text{walk to station in } w, \\ \lambda w_s.\text{walk to palace in } w, \\ \lambda w_s.\text{stay put in } w \end{array} \right\}$$

$$S = \left\{ \begin{array}{l} \lambda w_s.\text{newspaper available only at station in } w, \\ \lambda w_s.\text{newspaper available only at palace in } w, \\ \lambda w_s.\text{newspaper available at both locations in } w, \\ \lambda w_s.\text{newspaper available at neither location in } w \end{array} \right\}$$

$U(\lambda w_s.\text{go to station in } w, \lambda w_s.\text{paper only at station in } w) = 1$
$U(\lambda w_s.\text{go to palace in } w, \lambda w_s.\text{paper only at station in } w) = -1$
$U(\lambda w_s.\text{stay put in } w, \lambda w_s.\text{paper only at station in } w) = 0$
etcetera.

If Italian newspapers are available at the train station, then I do well to go there. Same thing with the palace. But if I can get a paper at neither place, then I am better off staying where I am, as I am bound to lose a util no matter where I walk.

6.2 DPs in context

To situate decision problems in a broader account of discourse structure, our next step is to generalize the topic stacks from Section 4 to *goal stacks* by letting DPs coexist alongside questions in these data structures (cf. the shift from "information structure" to "intentional structure" in Roberts 2004, 2012a, 2015, 2018; you can think of the theory-building in this section as an attempt to flesh out some aspects of Roberts' intentional structure in a decision-theoretic way):[47]

[47]We work with a single goal stack to keep things relatively straightforward, but there are many other modeling choices; for example, one could have separate QUD and DP stacks, or have more complicated tree or graph structures (perhaps with the goal nodes connected with discourse coherence relations) as in theories like SDRT.

(91) **Contexts** v. 2

A *context* c is a tuple $\langle cs_c, a_c, \mathcal{A}_c, \mathcal{G}_c \rangle$ with $cs_c, a_c \subseteq \mathcal{W}$ as before but where the table now includes a goal stack $\mathcal{G}_c$ loaded up with both DPs and question denotations in addition to the assertion stack $\mathcal{A}_c$.

Each element on $\mathcal{G}_c$ encodes a mutually recognized discourse or domain goal of one or more speakers, having been explicitly introduced or made salient in prior conversation. Living within $\mathcal{G}_c$ is the (possibly empty) substack $\mathcal{G}_{Q_c}$ of questions awaiting resolution. This representation of the speakers' common interrogative goals is just the topic stack from our earlier tables relabeled. The remaining elements on $\mathcal{G}_c - \mathcal{G}_{Q_c}$ are DPs representing any public domain goals of the speakers in the discourse. The speakers will of course have all sorts of real-world goals and interests at the time they are talking, but the goals reified on the stack as DPs are those immediately relevant to the conversational exchange that is directed at resolving them. We reference this (possibly empty) substack of DPs with the notation $\mathcal{G}_{DP_c}$.

As before, the goals on $\mathcal{G}_c$ are interpreted through the lens of the current discourse context. The current QUD in context can still be defined as in (59) simply by replacing $\mathcal{Q}_c$ with $\mathcal{G}_{Q_c}$:

(92) **QUD in context** v. 2

Where c is a context,

$$\text{QUD}_c = \begin{cases} (cs_c \cap a_c)/\sim_{top(\mathcal{G}_{Q_c})} & \text{if } \mathcal{G}_{Q_c} \neq \langle\rangle \\ \{cs_c \cap a_c\} & \text{otherwise} \end{cases}$$

Given our decision-theoretic upgrade, we can also define the analogous concept of a DP *in context*. This is generated by restricting the top element of the DP substack, $top(\mathcal{G}_{DP_c})$ (the "current DP"), to the live alternatives in the context. We intersect the elements of its action set and state space with $cs_c \cap a_c$ (holding onto nonempty propositions) and assign each of the resulting action-state pairs the same utility as the pair it was derived from (cf. Cariani, Kaufmann & Kaufmann's 2013 "filtered decision problems"):[48]

[48] In restricting DPs, there is the danger of starting off with a well-formed decision problem and ending up with a subproblem that is not well-formed. However, we assume that rational discourse develops in such a way that the contextually-restricted decision problems of speakers (if any) are well-formed. We also make the simplifying assumption that new information does not change the utilities assigned to outcomes.

(93) **Restricting DPs**

Given a decision problem $DP = \langle A, S, U\rangle$ and proposition P, $DP \otimes P = \langle A', S', U'\rangle$ where

a. $A' = \{a \cap P : a \in A\} - \{\varnothing\}$

b. $S' = \{s \cap P : s \in S\} - \{\varnothing\}$

c. $U'(a \cap P, s \cap P) = U(a, s)$ (where $a \cap P, s \cap P \neq \varnothing$)

(94) **DP in context**

Where c is a context,

$$\text{DP}_c = \begin{cases} top(\mathcal{G}_{DP_c}) \otimes (cs_c \cap a_c) & \text{if } \mathcal{G}_{DP_c} \neq \langle\rangle \\ \text{undefined} & \text{otherwise} \end{cases}$$

Now recall the earlier relevance condition from Roberts discussed in Section 4, according to which the complete answers to questions higher up on the topic stack must partially answer questions lower down. We can now state a decision-theoretic analog of this: if the speakers' current goal is to resolve a DP on the goal stack, then the complete answers to any new question added to the stack should *help to resolve it*; that is, the speakers should ask questions as part of strategies for achieving their underlying domain goals, where the answers to their questions can ultimately help them decide what to do in the world. We take both of these relevance constraints to be operative in a discourse.

6.3 Subservience

When is a DP "resolved" exactly? And how can the answers to questions "help to resolve" DPs? To formalize the new notion of relevance that we are after, we follow van Rooy 2003b,a and first assign each action of a DP the set of states in which it is optimal (i.e., where there is no alternative action that is strictly better):

(95) **Best action sets** (BASes). Given a decision problem $DP = \langle A, S, U\rangle$:

a. The *best action set* for $a \in A$ is
$a^* = \{s : U(a, s) \geq U(b, s) \text{ for all } b \in A\}$

b. The *best action set* for DP is $Q_{DP} = \{\bigcup a^* : a \in A\}$

Notice our use of the notation "Q_{DP}" in (95-b) because the BAS for a decision problem is a Hamblin-style alternative set corresponding to the issue *What*

is the best thing to do?. In the Italian newspaper example (90), for instance, the best action set is:

$$Q_{(90)} = \left\{ \begin{array}{l} \lambda w_s.\text{newspaper available at station in } w, \\ \lambda w_s.\text{newspaper available at palace in } w, \\ \lambda w_s.\text{newspaper available at neither location in } w \end{array} \right\}$$

The top proposition $\bigcup(\lambda w_s.\text{walk to station in } w)^*$ is the union of the best action set for heading to the train station, the middle proposition $\bigcup(\lambda w_s.\text{walk to palace in } w)^*$ consists of those worlds in which heading to the palace is best, and the bottom proposition $\bigcup(\lambda w_s.\text{stay put in } w)^*$ consists of worlds in which you do well to stay where you are. Note that the first two alternatives overlap, as walking to either the station or palace hits the maximum utility if you can get an Italian newspaper at both locations.

We can define DP resolution in terms of BASes. Intuitively, a decision problem is resolved in a discourse context just in case one of the members of its action set restricted to the context has optimal consequences come what may. In this happy situation, there is no longer any uncertainty about how best to achieve the explicated domain goal:

(96) **Resolved DPs**. Given a decision problem DP,

a. DP is *resolved* iff $\bigcup S \in Q_{DP}$.

b. DP is *resolved in* c iff $DP \otimes (cs_c \cap a_c)$ is resolved.

Next, we can say that a proposition P resolves a decision problem DP iff informationally updating with this proposition takes us to a context in which this problem is resolved (van Rooy 2003b):

(97) **Resolving DPs**

Given a decision problem DP that is not yet resolved in c:

P *resolves* DP in c iff DP is resolved in $\langle cs_c \oplus_{a_c} P, a_c, \mathscr{A}_c, \mathscr{G}_c \rangle$.

It might help to think of (97) as the decision-theoretic analog of complete answerhood for questions.

The notion of "helping to resolve" a decision problem, which one might think of as the decision-theoretic analog of partial answerhood, is more complicated. Earlier in Section 4.2 when we introduced our `Assert` update (61), we noted how information that fails to eliminate any live options can still be relevant to a QUD by virtue of shifting probabilities over its alternatives or bringing new possibilities to a speaker's attention. Presumably, information

can also help to resolve a DP in context in these ways. However, if we focus exclusively on the world-excluding impact of assertion, then we can define a relatively straightforward notion of partial resolution for decision problems. The basic idea is this: a proposition P helps to resolve a DP in context iff P rules out at least one member of either its contextually restricted action set or state space and in so doing brings the decision maker closer to a situation where her choice is clear.[49] But, importantly, not just any action or state will do. Regarding actions: P helps to resolve the DP only by eliminating a potentially optimal action a that is "in play" in the sense that there is no alternative action b that is optimal in all of the same states as a and in some additional ones besides; if there is such an alternative action b, then eliminating a needn't help to resolve the DP since b is strictly closer to being a resolving action anyway. Regarding states: P helps to resolve the DP only by excluding a "conflict state" where some action in play is optimal while some other action in play is not, thereby helping with the choice between these competing actions.

This proposal can be formalized as follows:

(98) **Acts in play & conflict states**

Given a decision problem $DP = \langle A, S, U \rangle$:

a. Action $a \in A$ is *in play* iff there is no $b \in A$ s.t. $a^* \subsetneq b^*$.

b. State $s \in S$ is a *conflict state* iff there are actions $a, b \in A$ in play such that $s \in a^*$ but $s \notin b^*$.

(99) **Helping to resolve DPs**

Given a decision problem DP that is not yet resolved in c,
P *helps to resolve* DP in c iff one of the following holds:

a. $P \cap a = \varnothing$ for some action a of $DP \otimes (cs_c \cap a_c)$ in play, or

b. $P \cap s = \varnothing$ for some conflict state s of $DP \otimes (cs_c \cap a_c)$.

It follows from our definitions that information which resolves a DP also helps to resolve it, but the converse needn't be true.

We are now in position to articulate more precisely the DP-based relevance constraint from the end of Section 6.2. Working alongside the felicity conditions in our earlier `Question` update (64), we assume that the following felicity condition governs both conditional and unconditional question-introducing speech acts:

[49] We implicitly assume that the new information P is *wholly about* either the action set or state space in the sense of Lewis 1988a.

(100) **Subservience**

If the speakers in c face a decision problem $top(\mathscr{G}_{DP_c})$ that is not yet resolved in c (i.e., DP_c is unresolved) and a speech act is performed that results in a new question Q being pushed onto the goal stack, then this speech act is appropriate only if completely answering Q (in the sense of (57-b)) helps to resolve DP_c (in the sense of (99)).

For example, if a speaker asks a conditional question using $\ulcorner$*if* φ, ψ?$\urcorner$ in c and thereby shifts the context to c + `Assume`(φ) + `Question`(ψ?), then the complete answers to $[\![\psi?]\!]$ in this posterior context must each help to resolve the current DP *in the initial context* c. Importantly, it does not suffice that the answers to $[\![\psi?]\!]$ help to resolve the current DP in the local context c + `Assume`(φ); indeed, as we will later see in Section 8, the current DP might already be resolved in this local context.

We began Section 6.1 with the informal platitude that speakers in practical contexts will generally take up questions the answers to which can help them achieve their real-world domain goals and plans. Though such an idea is difficult — perhaps impossible — to formalize perfectly, we now have a first-draft working theory that implements it. In the next two sections, we put this theory to work. We consider a couple of cases where challenging and suggestive *what if*s trigger QUD accommodation and show how the Subservience condition (100) constrains the repair possibilities in these examples.

7 Case study: resisting commands

We will revisit the troublesome colloquium example (86) that led us to introduce DPs in the first place in the next section, but first we want to consider a *what if* question used to challenge a command.

(101) A: Open the window.
B: What if it's raining?
A: Oh, in that case, I want it to stay closed.

This example is in some respects easier to think about, so it serves as a nice warm-up. Furthermore, unless A's discourse-initial imperative introduces a new QUD or responds to a prior QUD already in place, it is like the QUD-less hypothetical cases discussed in Section 5 and so provides a welcome opportunity to address any lingering concerns that the repair in such examples leaves things too unconstrained.

With the *what if* question, B is effectively asking something like this (as revealed by A's follow-up response):

(102) If it's raining, do you still want me to open the window?

But how can we recover this result? Since we aren't looking to defend a full theory of imperatives here, feel free to think of A's directive as adding the property of opening the window to B's "To-Do List" (Portner 2004, 2007, cf. Roberts 2004, 2015, 2018), issuing a performative using a deontic modal (M. Kaufmann 2012), expressing an "effective preference" for the window to be open (Condoravdi & Lauer 2012), or performing some other function. We require only two things. First, that the denotatum of A's imperative (whatever it is) together with the conditions of authority and deference in the context of issuance make it such that B now faces a decision problem — he wants to satisfy A's wishes with respect to the window but thinks that A may have failed to consider the possibility that it is raining when issuing her command, so B is not sure whether opening the window is in fact the thing to do. And, second, that this decision problem (call it "DP_{B}") is added to the goal stack at some point before B's *what if* question is processed.[50]

Bracketing off any other discourse effects of A's imperative, let us take up the example in the context $c_0 = \langle cs_{c_0}, \mathscr{W}, \langle\rangle, \langle DP_{\text{B}}\rangle\rangle$, which has an empty assumption slot, empty assertion stack, and B's decision problem sitting on the goal stack ready for his *what if* question to exploit. Applying the *what if* update intersectively updates the assumption slot with the proposition that it is raining:

$$\begin{aligned} c_1 &= c_0 + \textit{What if it's raining?} \\ &= c_0 + \texttt{Assume}(\textit{It is raining}) \text{ (+QUD}_c \text{ on CQ version)} \\ &= \langle cs_{c_0}, [\![\textit{It is raining}]\!], \langle\rangle, \langle DP_{\text{B}}\rangle\rangle \end{aligned}$$

The state space of B's decision problem DP_{B}, when restricted to $c_0 + \texttt{Assume}(\textit{It is raining})$ and represented by the light grey columns in the decision matrix in Table 2, partitions the raining-worlds in the context set

[50] We do assume that, as part of practical discussion, agents coordinate about decision problems, and that this often happens implicitly — and therefore we require DP-accommodation in the same way that many pure QUD-based theories of discourse require QUD accommodation. While it might be that DP_{B} gets pushed directly onto the goal stack by A's command, we find it more plausible that this uploading happens only after B's *what if* response when his unresolved decision problem becomes public. So long as the push still precedes the *what if* update itself, this is compatible with our analysis. There is clearly more to understand about the process by which agents coordinate on their domain goals.

	rain and A wants open	rain and A wants closed	no rain
open window	1	0	1
keep closed	0	1	0

Table 2 Decision matrix for resistance use in (101)

into those in which A wants the window open (regardless of rain) and those in which she wants it closed.

Assuming that A's command did not raise or respond to a QUD, B's challenging *what if* must also adjust the discourse context to ensure that there is a question available for re-asking (on the CQ analysis) or that the inquisitivity requirement is met (on both the CQ and SQ analyses). Which question gets added to the goal stack $\mathcal{G}_{c_1}$? Back in Section 5, we would have simply said "some coarsening of the Big Question" and left things pretty much at that. But we can now offer this more precise answer: "some question the complete answers to which each help resolve B's decision problem in c_0 (i.e., DP_{c_0})". If we restrict attention to questions that aren't about B's behavior (i.e., whose answers cannot exclude an action of DP_{c_0} that is in play), then the accommodated question must be one whose answers exclude at least one of the light grey columns of the above decision matrix — these are both conflict states of DP_{c_0} as opening the window is preferred if it rains but A wants the window open, while keeping the window closed is preferred if it rains and A wants the window closed (and both actions are in play).

One obvious candidate is the BAS of B's current decision problem restricted to the local context $c_0 + \texttt{Assume}(\textit{It is raining})$:

$$Q_{\mathrm{DP}_{c_1}} = \left\{ \begin{array}{l} \lambda w_s.\text{rain and A (really) wants the window open in } w, \\ \lambda w_s.\text{rain and A wants the window closed in } w \end{array} \right\}$$

Note that various more fine-grained questions would also fit the bill. But it is presumably a rational requirement of practical questioning that one avoid unnecessary processing costs by not asking for extra irrelevant information to decide what to do (van Rooy 2003b). So we take it that A will accommodate with $Q_{\mathrm{DP}_{c_1}}$ rather than some more specific question that also satisfies Subservience:

$$\begin{aligned} c_2 &= c_1 + \texttt{Repair!} \\ &= \langle cs_{c_0}, [\![\textit{It is raining}]\!], \langle\rangle, \langle Q_{\mathrm{DP}_{c_1}}, DP_{\mathrm{B}}\rangle\rangle \end{aligned}$$

This yields the intuitively correct result. Suppose we had instead updated c_0 with the conditional interrogative (102):

$$c_2' = c_0 + \texttt{Assume}(\textit{It is raining}) + \texttt{Question}(\textit{Does A want open?})$$

Then we would have ended up in a discourse context with the same assumptions and open QUD in context as c_2. The `Assume` + `Repair!` steps launched by B's *what if* thus together simulate the dynamics of the conditional question. With his *what if* question, B is effectively asking (102) as desired.

At the end of (101), A answers this question:

$$\begin{aligned} c_3 &= c_2 + \texttt{Assert}(\textit{A wants closed}) + \texttt{Accept} + \texttt{Dispel} + \texttt{Clear} \\ &= \langle cs_{c_0} - [\![\textit{It is raining and A wants open}]\!], \mathscr{W}, \langle\rangle, \langle DP_{\mathrm{B}}\rangle\rangle \end{aligned}$$

This helps to resolve DP_{c_0} as required by Subservience by ruling out the state where it is raining and A nevertheless wants the window open (the leftmost column of the decision matrix). At this point, B's decision problem is not yet resolved; whether opening the window or keeping it closed is the best move still turns on whether it is in fact raining. However, B can easily acquire this resolving information by just walking over to the window and looking outside.

8 Case study: suggestive uses

The analysis of our colloquium example (86) proceeds along similar lines, but there are some twists.

(103) A: Who are we going to invite to speak at the next colloquium?
B: What if we invite Professor Plum?
C: He'll give a phonology talk.
A: That would be our third one in a row. Let's invite Professor McGonagall or Professor Xavier instead.

Suppose we are working our way through the agenda at a meeting when the chair broaches the subject of colloquium scheduling with the lead-off question in (103). How does this change the discourse context? Well, first and foremost, this adds the denotation $[\![\textit{Who will we invite?}]\!]$ from (87) to the goal

	Professor Plum gives semantics talks	Professor Plum gives phonology talks
invite Professor Xavier	0	1
invite Professor Plum	1	0
invite Professor McGonagall	0	1

Table 3 Decision matrix for suggestive use in (103)

stack. The chair's question also has a secondary effect: because this question clearly subserves (and is mutually understood to subserve) our common domain goal of hosting a successful colloquium, the question raises the domain goal to salience.

Let us begin our analysis in the following context, where our goal of hosting a good talk is represented by the decision problem DP_{C}, which rests below the chair's question on the goal stack:

$$c_0 \quad = \quad \langle cs_{c_0}, \mathscr{W}, \langle\rangle, \langle [\![\textit{Who will we invite?}]\!], DP_{\mathrm{C}}\rangle\rangle$$

B's suggestive *what if* question highlights the option of inviting Professor Plum:

$$\begin{aligned} c_1 \quad &= \quad c_0 + \textit{What if we invite Professor Plum?} \\ &= \quad c_0 + \texttt{Assume}(\textit{We invite Plum}) \ (+\mathrm{QUD}_c \text{ on CQ version}) \\ &= \quad \langle cs_{c_0}, [\![\textit{We invite Plum}]\!], \langle\rangle, \langle [\![\textit{Who will we invite?}]\!], DP_{\mathrm{C}}\rangle\rangle \end{aligned}$$

This time around the `Assume` step restricts the action set of the current DP, so the attendees come to focus on a row of the decision matrix in Table 3 (for ease of exposition, we assume that Plum, McGonagall, and Xavier are the only candidate speakers, that we want to invite Plum if he will give a semantics talk, and that we otherwise want to invite either McGonagall or Xavier but are indifferent between them):

Now recall the trouble: though there is a question $[\![\textit{Who will we invite?}]\!]$ sitting on top of the goal stack $\mathscr{G}_{c_1}$, it does not partition the light grey invite-Plum row into multiple cells. So the inquisitivity condition of the *what if* update is violated and the context must be repaired.

Fortunately, as in our previous case study in Section 7, the decision-theoretic structure in c_1 helps to narrow the repair options. Given that we are

presently focusing on the possibility of inviting Professor Plum, it is natural to assume that we will accommodate with the coarsening of the state space of the current DP that concerns him—call this "Q_{Plum}":[51]

$$\begin{aligned} c_2 &= c_1 + \texttt{Repair!} \\ &= \langle cs_{c_0}, [\![\textit{We invite Plum}]\!], \langle\rangle, \langle Q_{Plum}, [\![\textit{Who will we invite?}]\!], DP_C\rangle\rangle \end{aligned}$$

In our simplified setting:

$$Q_{Plum} = \left\{ \begin{array}{l} \lambda w_s.\text{Plum gives semantics talks in } w, \\ \lambda w_s.\text{Plum gives phonology talks in } w \end{array} \right\}$$

So B is effectively asking the following conditional question:

(104) If we invite Plum, will he give a semantics or phonology talk?

More generally, B is asking the following question:

(105) If we invite Plum, then what will things be like Plum-wise that bear on whether we made the best choice?

C goes on to answer this question:

$$\begin{aligned} c_3 &= c_2 + \texttt{Assert}(\textit{Plum will give a phonology talk}) \\ &= \langle cs_{c_0}, [\![\textit{We invite Plum}]\!], \langle [\![\textit{Plum will give a phonology talk}]\!]\rangle, \\ &\quad \langle Q_{Plum}, [\![\textit{Who will we invite?}]\!], DP_C\rangle\rangle \end{aligned}$$

After this assertion is accepted, Professor Plum is out of the running.

There is a complication, though.[52] Note that if we apply our earlier domain-restricted informative update (62) when C's reply is accepted, then this removes the possible worlds from the context set in which we invite Professor Plum and he gives a semantics talk but leaves any world in which we fail to invite him untouched (in the decision matrix, the update eliminates only the left-middle cell, not the full left column). So, strictly speaking, C's answer does not help to resolve DP_{c_0} as required by Subservience. But, intuitively, it does help: though the presence of *will* in C's response indicates subordination under the supposition that we will invite Plum to speak, and

[51] Suppose, following Lewis 1988a, that Professor Plum determines a subject matter (i.e., a partition of a subset of $\mathscr{W}$) that groups together worlds that are exactly alike with respect to his state. More accurately, we can take Q_{Plum} to be the finest common coarsening of this "Plum matter" and the partition of conflict states of the current DP. See Lewis 1988a,b, Yablo 2014 for more on the mereology of subject matters.

[52] In the rest of this section, we discuss an extension of our formal system needed to make sense of how B's suggestive *what if* satisfies Subservience. Because we present this formal patch fairly quickly and it isn't central to our analysis, readers who are experiencing fatigue at this late stage of the paper should feel free to skip ahead to the conclusion.

the information that Plum will give a phonology talk is clearly conditional on our invitation, C is also providing us with the unconditional information that Plum gives phonology talks, as Plum's research area is independent of our invitation.

The more general problem is that our update (62) is overly restrictive. When speakers convey information that is recognizably independent of what is being currently assumed in a context, we want to be able to unrestrictedly update the context set with this unconditional content. To implement this, let us now assume that each discourse context c comes equipped with a binary relation $\perp_c$ between propositions where $P \perp_c P'$ iff P and P' are independent.[53] For any asserted proposition $[\![\varphi]\!]$, we can then define the set of its contextual entailments in c that are independent of a_c (we require that $\mathscr{W} \in [\![\varphi]\!]_{\perp a_c}$ so this entailment set will be nonempty):

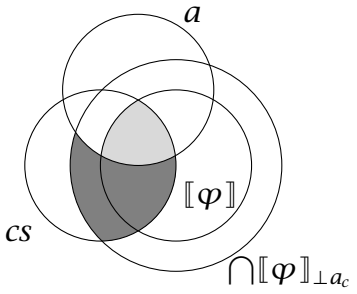
(106) $[\![\varphi]\!]_{\perp a_c} = \{P : [\![\varphi]\!] \cap cs_c \cap a_c \subseteq P \;\&\; P \perp_c a_c\}$

The fix is now to redefine our informative update so that it eliminates not only the not-φ-worlds in $cs_c \cap a_c$ (as before) but also any worlds throughout the rest of the context set that are excluded by a member of $[\![\varphi]\!]_{\perp a_c}$:

(107) **Informative update** v. 2

$$cs_c \oplus_{a_c} [\![\varphi]\!] = (cs_c \cap a_c \cap [\![\varphi]\!]) \cup ((cs_c - a_c) \cap \bigcap [\![\varphi]\!]_{\perp a_c}).$$

The intuitive idea is this. If an assertion is accepted, we should at least update $cs_c \cap a_c$ with its content $[\![\varphi]\!]$. However, because the assertion might depend on what is currently being assumed, we do not in general want to update the full context set cs_c with $[\![\varphi]\!]$. In contrast, any $P \in [\![\varphi]\!]_{\perp a_c}$ is independent of the current assumptions, so speakers can safely update the full context set cs_c with P. At one extreme where $(cs_c - a_c) \subseteq \bigcap [\![\varphi]\!]_{\perp a_c}$, the new update (107) coincides with the older update (62). At the other extreme where $[\![\varphi]\!] = \bigcap [\![\varphi]\!]_{\perp a_c}$, the assumptions are disregarded and the new update amounts to regular intersection: $cs_c \oplus_{a_c} [\![\varphi]\!] = cs_c \cap [\![\varphi]\!]$.[54]



Assuming that $[\![\textit{We invite Plum}]\!] \perp_{c_3} [\![\textit{Plum gives phonology talks}]\!]$, C's assertion now has the desired effect:

[53] This qualitative notion of independence might be spelled out as in Goebel 2017 using Veltman's 2005 'cognitive states' or by using the causal modeling apparatus of Pearl 2000.

[54] The update (107) allows a treatment of *biscuit conditionals* (BCs; Austin 1956, Franke 2009, Francez 2015; Goebel 2017; Biezma & Goebel *ms.*) and *biscuit what ifs* where 'nor-

$$\begin{aligned} c_4 &= c_3 + \texttt{Accept} + \texttt{Dispel} + \texttt{Clear} \\ &= \langle cs_{c_0} \cap [\![\textit{Plum gives phonology talks}]\!], \mathscr{W}, \langle\rangle, \\ &\quad \langle [\![\textit{Who will we invite?}]\!], DP_C \rangle\rangle \end{aligned}$$

By ruling out the entire left column of the decision matrix, it leaves the best action set for inviting Plum empty.

9 Conclusion

We have analyzed *what if* s as conditional/suppositional questions: they have the suppositional semantics of regular conditionals combined (at least) with a post-update requirement for an inquisitive context, a feature of questions in general. This, together with the integration of decision problems into discourse structure and general principles involving QUD accommodation, allowed us make progress on our central puzzle: accounting for the flexibility of *what if* in discourse. We have considered four main kinds of *what if* questions: hypothetical, elaborative, challenging, and suggestive. Hypothetical and elaborative *what if* s can involve accommodating relatively open ('Big') QUDs, which can be very fine-grained (and sometimes also counterfactual; cf. Ippolito 2013). Challenging *what if* s that resist answers to QUDs from prior discourse involve re-addressing the prior QUD in the face of the proposed resolution. Suggestive *what if* s, the most problematic case for Rawlins 2010, often involve accommodation with new QUDs constructed from contextually salient DPs in order to meet the inquisitivity constraint.

The fact that *what if* questions are so flexible follows from two main factors on our proposal: (i) the inquisitivity condition in the semantic entry for *what if*, and (ii) the range of maneuverability that agents have in discourse when trying to infer what QUDs their interlocutors intend. We have suggested that in general this accommodation obeys a number of constraints revealed by *what if* questions — constraints on what kinds of QUDs are available in

mal' biscuit conditional antecedents are posed as *what if* questions that license non-subordinated answers (Franke's "intelligibility conditionals" do not tend to work):

(i) There are biscuits on the sideboard if you want them.

(ii) A: What if I want some biscuits?
B: There are some on the sideboard.

Assuming that $[\![\textit{A wants biscuits}]\!] \perp_c [\![\textit{There are biscuits on the sideboard}]\!]$, accepting (i) or B's reply in (ii) will incorporate the unconditional information that there are biscuits on the sideboard into the context set.

speculative hypothetical cases, constraints on how decision problems and QUDs interact, and so forth. An important part of our analysis has been a more general account of relevance to goals in discourse beyond just QUDs: *what if*s provide an argument for a model of discourse that allows for this sort of deeply underspecified move.

There are a number of open problems. One future task is to extend our system to handle related linguistic phenomena, like counterfactual *what if*s. There is also the pressing issue of how DPs become salient. Considering other morphology that interacts with DPs (Davis 2009, etc.) may help.

Though we spent much of this paper trying to account for the many things that speakers can do with *what if*, there are also certain things that one cannot do. As we have seen, *what if* questions can be used to respond to prior questions in their suggestive and challenging uses. However, *what if* is often infelicitous post-question:

(108) A: Who is coming to the party?
B: #What if Alfonso is coming?
B′: (Well,) Is Alfonso coming?

(109) A: Is Alfonso coming to the party?
B: #What if Joanna is coming?
B′: (Well,) Is Joanna coming?

It remains an outstanding problem to account for this negative distribution data and to articulate the contextual conditions under which the post-question restriction is relaxed. Doing so can help to clarify the collaborative or brainstorming function of many *what if* questions.

We have also been silent about the large family of related 'discourse conditionals' both in English and in other languages that have *if*-clauses with some minimal extra morphology but no obvious consequent: for example, *what/how about if...?*, *even if...?*, *and if...?* in English.

(110) A: Alfonso's coming to the party.
B: What about if Joanna is there?
B′: Even if Joanna is there?
B′′: And if Joanna is there?

These data raise a number of puzzles for the analysis of conditionals in general. If, as we have suggested, *what if* questions are consequent-less conditionals, then any theory of conditionals that deeply relies on the existence of

some kind of consequent might need to be revisited. For example, if conditionality relies on a main-clause operator (a position defended by many researchers in linguistics beginning with Lewis 1975, Kratzer 1977, 1986, Heim 1982, including one of the authors of this paper in Rawlins 2008), what do we make of the fact that there is no evidence for such an operator in *what if* s? The success of this account is prima facie evidence for a suppositional account of *if*-clauses, and works against accounts of conditional compositionality that structurally require the *if*-clause to interact with an operator (e.g., the restrictor account as usually implemented). This is not to say that we want to reject the insights of such a theory, but rather we suggest that this treatment of *what if* s calls for a reconciliation between the kind of suppositional view we advocate here and the data motivating the restrictor account. This reconciliation, necessary though it may be, has only begun, and we suggest that broader investigation of discourse conditionals both in English and across languages provides an important new direction for research on conditionals.

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