Accepting and resisting inquiry

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1 A puzzle

Cooperative communication goes something like this. Speakers assert propositions. These propositions are accepted by the interlocutors if the interlocutors take the propositions to be true.[1] This is an all too familiar story—one we know from Stalnaker (1978). To use a metaphor from Lewis (1979), in the course of a dialogue, participants add to the scoreboard. In the past two decades, two pressures have guided addition of more structure to the scoreboard: (i) making modeling of communication less idealized; (ii) more empirical coverage.[2] (i) and (ii) usually go hand in hand. For instance, although Stalnaker took assertion of p to be the proposal to make p common ground, the proposal nature of the assertive move wasn't modeled. In modeling the tentative nature of a proposal, Farkas and Bruce (2010) explain a uniformity in responses to assertions and questions.

Given that assertion, at its core, is a proposal, it can be accepted, rejected, or as Bledin and Rawlins (2020) explore, resisted. The notion that comes out to be crucial in modeling an interlocutor's (lack of) uptake for a proposition p is the interlocutor's belief in p's truth.[3] In this paper, we probe for an answer to the blank in (1):

[1]Of course, this is an idealization, as Yalcin (2012a) notes that participants don't take home all of what they let be common ground.

[2]This includes modeling of clause types as in Roberts (2012); Farkas and Bruce (2010), and also the cross-linguistic work on discourse particles Yuan (2020); Theiler (2021); Jabbar (fc); Jabbar and Kanamarlapudi (2023).

[3]There are obviously other reasons for (lack of) uptake. For now we austerely limit our comment to the context of inquiry as in Stalnaker (1984), while making the idealizing assumption that participants at least aspire to be cooperative. See Nowak (fc) for lack of attention towards sociolinguistic phenomena in the model-theoretic tradition, going back to philosophical work on meaning. Also see Bird (2002); Fricker (2007); Hesni (2018) for social issues surrounding knowledge, speech acts, and their uptake.

(1) In the context of uptake, truth is to assertion as ____ is to question.

Let's make our question more vivid. A speaker asks a question q in a conversation. That q is taken up in conversation and made the question under discussion (QUD) is not a given—just like it's not a given that every asserted proposition is made common ground. Just like assertions can be rejected or resisted, questions can have no uptake either. Consider (2), given the context MOVIE.

[MOVIE]: A and B plan to watch a movie at night. It's currently noon. A and B are working on a problem set. B has a focused attitude towards work and doesn't tolerate distractions. To B's annoyance, A is distracted.

(2) A: We can either watch Oppenheimer or Barbie. Which one should we watch?
B: Drop it dude! Let's focus!

Note that B hasn't answered A's question. Instead, B just rejects taking it up as the QUD. Contrast MOVIE and (2) with NIGHT and (3).

[NIGHT]: It's night time now. The problem set is done. A and B are walking to the cinema, both excited to make the most of their evening.

(3) A: We can either watch Oppenheimer or Barbie. Which one should we watch?
B: Hmm I like Gerwig's films. Are those the only options though?
A: We can also watch Past Lives.

In (2), A's question is not accepted to be made QUD, while in (3), B takes the same question up for inquiry and tries to do their part in resolving it.[4] What's the upshot? Just how assertions are accepted to be made common ground, questions are also accepted to be made QUD and their resolution pursued in conversation. However, crucially, we cannot take B's belief in truth of a salient proposition to guide B's uptake for A's question in (3). So we ask (4).

(4) What guides uptake of questions in conversation?

(4) is a more straightforward way to ask (1). The answer to (4) that we explore in this paper is the following: it is the expected utility value (EUV) of questions that guides their uptake. One argument for using EUV of a question q to guide q's uptake is that EUV can be easily incorporated in a formal model of discourse to make predictions about question uptake. Our paper is supposed to present an implementation of this incorporation. Moreover, the use of EUV saves us from

[4]Although nothing hinges on this, we borrow the *doing one's part* locution from Khoo (2015).

making many idealizing assumptions in conversational dynamics, as we illustrate in §5. In other words, using EUV, we enrich the discourse structure model, known to us from Stalnaker (1978); Roberts (2012); Farkas and Bruce (2010); Yalcin (2012b), with data structures that equip procedural sufficiency for question uptake and hopefully explain the difference between A's response in (2) and (3). To state it explicitly, our aim in this paper is two-fold. First, we enrich the discourse structure by incorporating a decision-theoretic component. Second, using this component, we explain agent behavior in discourse when it relates to uptake of questions. We conclude by raising issues and noting limitations for the answer we present for (4).

Plan: In §2, we give the reader a brief primer on discourse structure. This mainly includes discussion of common ground and QUD. §3 comprises the bulk of our paper: we introduce the notion of EUV, using van Rooij (2003)'s insightful work on interpretation of questions; we introduce a data structure that we term *issue commitments*; we explain how EUV relates to the issue commitments. In §4, using the machinery introduced in §3, we look at contexts to illustrate how one may use our model to explain a wide range of empirical phenomena, including off-task interaction, prompted via questions prepended with *by the way*.[5] In §5, we discuss the promise and the limitations of our account. Here, we also compare our model with a seemingly similar model in Bledin and Rawlins (2019)'s brilliant paper.

2 A primer: to common ground

Here, we briefly go over a few important notions from the conversation update literature. First take common ground. Although used widely in linguistics, psychology, and philosophy (cf. Clark et al. (1983); Grice (1989)), the treatment of common ground relevant for our purposes can be found in Stalnaker (1978)'s work. First, the common ground is defined as the set of propositions that interlocutors take to be publicly accepted in the conversation.[6] This is formally useful. Propositions can be taken to specify a set of worlds. Then, a formal counterpart to common ground can be the set intersection of all propositions that are common ground. Following Stalnaker, call this *the context set*. As propositions and context-set have the same semantic type, i.e. $\langle s, t \rangle$, successful assertion can be

[5]See Abulimiti et al. (2021) for recent work on off-task interaction and rapport-building.

[6]Usually, common ground is defined using recursive knowledge ascriptions (cf. Stalnaker (2002)). See Lederman (2018) for arguments against this approach.

modeled as set intersection. Where cg is common ground, cs is context set, and $cs[.]$ is context set update,

(5) $W = \{w \mid w \text{ is a world}\}$

(6) $p = \{w \in W \mid p(w) = 1\}$

(7) $cg = \{p \mid p \text{ is common ground}\}$

(8) $cs = \bigcap cg$

(9) $cs[p] = cs \cap p$

Now, assertion is not all that there is to conversation. People wonder. Pursuing questions to resolve is a hallmark of shared inquiry. To model the discourse move of asking questions, both Ginzburg (1996) and Roberts (2012) introduce the notion of question under discussion (QUD). The thought is that if a question is taken up for cooperative discussion, all the moves that follow are guided by the QUD. Either the move is a (partial) answer to the QUD or a subquestion to the QUD. That's one way to understand relevant moves.

There are two things to separate here. First, there's the update effect of questions. Second, there's the storage device that keeps track of questions to be pursued. The storage is simply a stack with push and pop operations on questions. The question that lies on the top of the stack is the QUD. If a subquestion to QUD is asked, it gets put on the top of the QUD. The subquestion's resolution leads to its popping, which reveals the question underneath. This is one way of procedurally understanding the dynamics of conversation w.r.t. question resolution. One can already see a trajectory in the literature. In procedurally capturing dynamics of conversation, more structure is added to the conversational scoreboard.

We conclude our discussion for this short section with two major takeaways. First, although a lot of work has gone into question resolution, to our knowledge, the question of factors that guide question *uptake* haven't been systematically studied. However, two closely-related topics have received attention. These guide our inquiry into question uptake. First, how interlocutors interpret questions as in van Rooij (2003). Second, why speakers ask the questions that they do Hawkins et al. (2015). Both of these topics are inter-related, and highlight the importance of agent goals in better understanding the conversational dynamics surrounding questions. We explore how the same notion, speaker goals, can be used to understand question uptake.[7] More specifically, in the next section, we

[7] See Bledin and Rawlins (2019) for a similar approach. We note differences with this approach in our conclusion.

build a model incorporating a decision-theoretic component in a conversational update model of discourse.

We seek to achieve three aims via this incorporation. First, we take this to provide an answer to (1), the question we posed at the outset. Second, our model serves as a proof of concept, much like Bledin and Rawlins (2019), although diverging in crucial respects, for an incorporation of decision-theory to discourse structure that procedurally explains conversational dynamics of questions. Third, we illustrate the use of this model by explaining data that boil down to question uptake such as the difference between (2) and (3).

3 The value of questions

In this section, we present our model. The notion of expected utility value is crucial for our purposes. Therefore, in the first subsection here, we explain van Rooij (2003)'s co-opting of statistical decision theory for explaining interpretation of questions. We then use it in building our model.

3.1 The expected utility

Consider two questions (10) and (11). Let the context be such that the department hired three people in total and there are many places that sell newspapers.

(10) Who did the department hire?

(11) Where can I buy a newspaper?

(12) They hired John.

(13) Sam's coffee shop.

To bring out the difference between (10) and (11) in a very intuitive manner, consider a scenario where (10) and (11) are answered by (12) and (13) respectively. Moreover, let (12) and (13) not carry the prosodic contour associated with partial-answerhood.[8] While (12) may be considered misleading as an answer to (10), (13) would not be considered as misleading. This intuitive difference in the ways (10) and (11) receive complete answers underlies what is called *exhaustivity* in

[8] See Xiang (2022)'s super insightful work that carefully explores many issues related to the exhaustivity inferences in questions.

questions. For convenience, the varying levels of exhaustivity, at a higher level of grain, are divided into mention-some and mention-all.[9]

van Rooij (2003) presents a decision-theoretic explanation for how questions like (11) typically receive the mention-some reading. The guiding thought is that the answerer makes an inference about the questioner's goals and chooses an answer accordingly. The goals can happen to be such that a single answer to the question can help the questioner fulfill those goals. Although there's work that explores how speakers may choose answers Benz (2006), van Rooij (2003) explores a step prior to answering: how a question receives a given reading. For van Rooij, the answer lies in expected utility value of questions.

Following van Rooij, we take a decision problem to be a sequence $\langle P, U, A\rangle$ s.t. P is a probability function assigning credences to $w \in W$ where W is a set of worlds, $a \in A$ is an action, and U is a utility function s.t. $U\colon A \times W \rightarrow \mathbb{R}$. We take the expected utility (EU) of action a to be provided by (14) and EU of a given proposition C by (15), where P_C is P conditionalized on C:

(14) $EU(a) = \sum_{w \in W} P(w) \times U(a, w)$

(15) $EU(a, C) = \sum_{w \in W} P_C(w) \times U(a, w)$

Let's break down (14) and (15) into words. (14), given a set of possible state of affairs, just averages over the interaction of one's credence for a state of affairs with the utility one assigns to the given action in that world. For instance, say you're thirsty. You may assign high utility to drinking sugary drinks in a world where they're not bad for you; however, your credence that the actual world is such a world is pretty low. On the other hand, you may assign moderate utility to drinking water in a world where water provides hydration; and, your credence that the actual world is such a world is pretty high. Then (14) averages over these considerations to yield a high expected utility for drinking water. (15) does everything that (14) does. In addition, (15) just takes in a specific piece of information C and returns the expected utility, having updated your credences given C.

We can take $max_{a \in A}$ below to yield the highest value for the function in its scope with respect to $a \in A$. Now, we can let $UV(C)$ as defined in (16) reflect the utility value of information C.

(16) $UV(C) = max_{a \in A} EU(a, C) - max_{a \in A} EU(a)$

[9] The mention-all category can be further divided into strongly exhaustive, weakly exhaustive, and intermediately exhaustive. See Klinedinst and Rothschild (2011); Cremers and Chemla (2016).

As van Rooij notes, this notion has been used in the literature before.[10] However, van Rooij nicely uses it to come up with an appropriate way to define the utility value of a question. Where Q is a question, let $\{q : q \in Q\}$ be the set of answers to Q. Then the expected utility value of Q, $EUV(Q)$ can be defined as in (17).

(17) $EUV(Q) = \sum_{q \in Q} P(q) \times UV(q)$

We use the EUV measure as defined in (17) for determining the question which becomes the QUD. To be able to implement this procedurally, we introduce a set of what we call *issue commitments*. We discuss this component in the next subsection.

3.2 Issue commitments

We take inspiration from Gunlogson (2008) and Farkas and Bruce (2010) here. Gunlogson introduces a set of discourse commitments which are relativized to participants in the discourse. For instance a discourse commitment set DC of agent x as in DC_x represents the commitments of the agent. Then, in addition to common ground, we can represent individual commitments as part of the discourse structure. Similarly, we can introduce a set of questions. Let's call this *issue commitments*, IC for short. We build the structure of this set incrementally. First, an IC is relativized to a participant as in IC_x. IC_x contains all of the questions that x wants to pursue in a discourse. Note that in this way, IC differs from DC; DC_x doesn't contain the propositions that x wants to make common ground. Moreover, it's natural that there are some questions that an agent wants to pursue more than others. For instance, a traveler who is almost late to the airport might want to know the fastest way to the airport more than knowing whether they have an aisle seat. To achieve this preference, we propose the IC_x to be ordered. We let this ordering be provided by $EUV_x(Q)$, where Q is a question in IC_x, EUV_x is simply EUV relativized to the agent x, and $EUV_x(Q)$ is calculated via (17). This captures nicely the fact that the question *what is the fastest way to the airport?* may be more important for an agent who is almost late than for an agent whose flight leaves next month. Therefore, relativization of EUV to agents is a plausible step. We can let the order provided by EUV_x be denoted by $\leq_{EUV_x}$. We can recapitulate our proposals below.

(18) Each participant x in the discourse has an issue commitment set IC_x.

(19) IC_x contains questions that x wishes to pursue in the discourse.

[10] See Parikh (2010) for one instance.

(20) IC_x is ordered by $\leq_{EUV_x}$

Although we introduce the order $\leq_{EUV_x}$, to keep confusion at bay regarding the order direction, we compare the questions directly by value. For instance, if Q', as compared to Q'' has higher expected utility value for x, then we can simply say $EUV_x(Q') > EUV_x(Q'')$.

Note that our model proposes that there's a set of questions that participants want to pursue in a conversation. We have said nothing regarding how this set comes about. We simply assume its presence.[11] With the above structure introduced, using our model, we put forward some conditions that guide conversational dynamics surrounding question asking and their uptake.

3.3 Question dynamics

Suppose that a speaker asks a question Q. Although we don't commit to the conditions for which questions get chosen to ask, (21) seems like a reasonable condition, reflecting previous research on question asking (cf. van Rooij (2003); Hawkins et al. (2015)).

(21) A speaker x asks Q iff $\forall Q' \in IC_x : EUV_x(Q) \geq EUV_x(Q')$

(21) amounts to saying that the speaker asks the question to which they assign the highest utility. This is a strong condition, but we don't discuss its plausibility, as the conditions we're interested in exploring are not that of question asking, but of question uptake. Recall that the answer that we're interested in exploring to (1) is EUV. We are ready to show how EUV becomes important for question uptake.

Let there be two discourse participants, A and B. A asks a question Q. In the Stalnakerian spirit for assertion, let the asking of Q be the proposal to make Q the QUD. When does B accept the proposal for Q to be made QUD? We provide two tentative answers to this question. We evaluate both of the answers below.

(22) B accepts Q only if $\forall Q' \in IC_B, EUV_B(Q) \geq EUV_B(Q')$

Now (22) is a very strong condition. It requires the asked question to be such that B assigns it more expected utility than any other question that B wants to pursue. If not strong, this is certainly an idealized condition. What makes it idealized, *inter alia*, is its super deterministic nature. (22) totally ignores the fact that some participants in conversation are more cooperative than others. Cooperativity is a

[11] It's quite possible that the underlying factors that generate such a set are those explored in Phillips et al. (2019); Morris et al. (2021) for modal cognition.

complex notion, and can be analyzed in many ways; here, we take it to be related to how single-mindedly one pursues their own goals. If one only pursues fulfilment of one's own goals, then we take such a participant to be uncooperative. Perhaps a better phrase to use would be *self-utility maximizing*. However, we think there's good reason to think of cooperativity in the terms stated, as cooperation is a broad notion that is taken to aid shared-inquiry, and exclusive self-inquiry, so to speak, seems antithetical to shared-inquiry. With these caveats and justifications in place, we note that our interpretation makes cooperativity a graded notion; participants can prioritize their goals to different extents. Then thought in terms of cooperation, (22) reflects the behavior of an uncooperative participant. But, not everyone is so uncooperative. In light of these considerations, we propose (23) instead.

(23) B accepts Q only if $EUV_B(Q) \geq k$

We can take k to be some threshold value that tracks B's cooperativity in the discourse. The prediction that comes out of (23) and our interpretation of k is that whether a given question Q gets taken up in the discourse depends on the cooperativity of B and the utility that B assigns to Q. Two special cases of (23) can define the behavior of a highly cooperative and an uncooperative participant. The highly cooperative participant will accept all questions and the highly uncooperative participant will accept none. Now, it's easy to explain the difference between (2) and (3). We take that task up in the next section.

4 Explanation

For ease, we have repeated (2) and (3) below as (24) and (25). The context for (24) is that A and B are solving the problem set. (25) occurs when A and B are walking to the cinema.

(24) A: We can either watch Oppenheimer or Barbie. Which one should we watch?
B: Drop it dude! Let's focus!

(25) A: We can either watch Oppenheimer or Barbie. Which one should we watch?
B: Hmm I like Gerwig's films. Are those the only options though?
A: We can also watch Past Lives.

In (24), B wants to work. Then, B's preferences are such that, in the context, B assigns lower importance to knowing the answer to *which film should we watch* *at night?*. If B had entertained the question despite B's preferences, we might have thought that B is an overly cooperative participant with a low k. However, B is not cooperative enough to accept and pursue the asked question. This is exactly what's described by our formalization in (23), which applied to (23) yields $EUV_B(\textit{which film should we watch?}) < k$. Thus B does not accept *which film should we watch?*. In (25) however B accepts the same question, as in the context, $EUV_B(\textit{which film should we watch?})$ is higher.

The explanation above highlights the importance of a threshold value k. It's quite clear that, the way the context is set up in (24), B assigns lower EUV to A's question. However, we don't want this to predict that B would never accept A's question in such a situation. Such uptake by B also depends on the sort of a discourse participant B is.

The above may seem simple. However, the ability for our model to predict the difference between the uptake of a question in two minimally different contexts and dialogues provides one answer to (1), the question we asked at the start. In the context of uptake, EUV is to questions as truth is to assertions. Further, we modeled the use of EUV procedurally to explain the difference in B's uptake of A's question in the two contexts. Before we move on to note its limitations, our model can also be used to capture another interesting difference.

Off-task interaction between interlocutors can serve a rapport-building purpose Abulimiti et al. (2021). A question prepended with *by the way* (*btw*) is an example of an off-task discourse move. However, sidestepping its rapport-building effect, it is striking that a *btw*-question is not deemed an uncooperative move.

Consider the following dialogue, where A is wondering about the ID they would need to show to get into the club. A and B are in the queue and A has realized that they left their driver's license in the car.

(26) A: Can I show my student ID?
B: Does it say your DoB on it?
A: Let me check.
B: By the way, was Jill at the party last night?

(27) A: Can I show my student ID?
B: Does it say your DoB on it?
A: Let me check.
B: Was Jill at the party last night?

Although not a subquestion to the question *can I show my student ID?*, in asking the *btw*-question as in (26), B doesn't seem to be acting like an uncooperative discourse participant. The addition of *by the way* is crucial for this effect, as, in (27), B's question *was Jill at the party last night?* seems abrupt and uncooperative. Although this effect of *by the way* may be modeled in other ways, our model can be used to capture this effect quite nicely without adding any more structure to the scoreboard.

Suppose that Q is QUD. We note that asking a *btw*-question signals to your interlocutor that you don't want to drop resolution of Q. Using our model, this can be captured as the speaker B, who asked the *btw*-question, simply signaling that $EUV_B(Q) \geq k$. As this is simply the condition for acceptance of Q when Q is proposed to be made QUD, communication of this preference, when Q is already QUD, signals that B hasn't dropped resolution of Q.

Above, we set aside the rapport-building purposes of off-task interaction in discourse. However, note that to accommodate the speaker question that is not a subquestion to the QUD, the interlocutor cannot have a very high k. For a highly goal-oriented participant, the only appropriate question to pursue while q is QUD is a subquestion to q. A *btw*-question that is accepted by a participant A, in our framework, signals that A's k isn't very high. The way we interpreted k above is such that communication of a not so high k for A corresponds to communication of A's cooperativity and a lower goal-orientedness. Such communication about each other's cooperativity and goal-orientedness is exactly what aids rapport-building. Abulimiti et al. (2021) explain rapport-building via off-task interaction more extensively than we do. However, the fact that our model can be used to explain such complex social interaction too is a nice add-on.

5 Discussion: promise and limitations

We used the metaphor of enrichment while describing the line of work that adds more structure to the conversational scoreboard models. The bedrock models in this literature are inquiry-based models. They take for granted that participants always have a shared inquiry to pursue—one that brings them closer to the actual world in the logical space, by ruling out worlds. This picture is thoroughly Stalnakerian as in Stalnaker (1978, 1984). Even Roberts (2012) defines relevant moves in terms of how they relate to the question under discussion. These are careful works that have brought insight into our understanding of clause-types, sentential force, etc. Moreover, these models bring procedural sufficiency to how discourse unfolds in the way they describe conversational dynamics. It is also true that these models take as their explananda, conversation and dialogue, which are seldom inquiry-based. Even when they are inquiry-based, they involve off-task episodes, as we noted above.

If the aim is to model conversation as faithfully as possible, then what guides uptake of questions is an important issue to address. Attention towards the tentative nature of assertion as in Farkas and Bruce (2010); Bledin and Rawlins (2020) has proven fruitful already. We have a better understanding of reaction moves to assertions and questions. We also have a better understanding of *might*-claims through their use in resisting assertions. Without a clearly understood notion that guides uptake of questions in discourse, we cannot understand the dynamics surrounding question uptake fully. Moreover, truth as a notion has been proven to be amenable even for understanding questions (cf. Karttunen (1977); Groenendijk and Stokhof (1982)). However, in the context of uptake of questions, it's not clear how truth in a proposition can be used. It is in the context of this difficulty that we take our work to be situated. Our answer was to use the notion of expected utility value (EUV), especially due to van Rooij (2003)'s insightful co-opting of it for questions.

One point of critique for our model may be that it uses utility theory, and in so doing, commits to the nebulous notion of utility, which can be interpreted as broadly as one wants. Then only in a superficial manner, does this provide us with an understanding of question dynamics. Such a critique wouldn't be fair. EUV of a question is quite clearly defined in terms of the information that one expects to get once the question is resolved. So, the notion of utility in our model, due to van Rooij (2003) does turn out to be clear. This is not entirely good news. We just noted in the above paragraphs that conversation is not entirely inquiry-based, and there are many off-task interactions. Then defining question uptake solely in terms of the information one expects to get via resolution takes us back into the idealized territory of inquiry. However, our model is not solely reliant on the notion of EUV. We concede that we introduce the idealization that participants rank questions within their issue commitment sets based on their expected utility. This perhaps limits the sort of questions that one asks in the discourse. However, for uptake of questions, we introduced another measure, k, which we interpreted as the measure of participant cooperativity towards others. Our model can be thought of as predicting question uptake by an agent A as a function of the interaction between A's preference for questions and A's degree of cooperativity. There are many factors that we haven't considered. These include the cognitive cost of engaging in discourse or that of speech production. These are real pressures that guide participant behavior in interaction.[12] These limitations aren't peculiar to our answer to (1) and our model. Even when it comes to uptake for assertion, pressures involving processing cost can influence uptake, as much as they can for questions. A fuller and more accurate exploration of the question we asked in (1) and (4) would require conducting psycholinguistic experiments to get a better sense of the factors that guide question uptake.

Lastly, we want to compare our model above with the one presented in Bledin and Rawlins (2019). Both models use decision theory with its connection to questions as in van Rooij (2003). Broadly, both models take questions in conversational dynamics as their explananda. However, the two models are far apart from each other at a closer look. First, Bledin & Rawlins are interested in explaining the dynamics of *what if*-questions. These questions can serve multiple purposes like suggestions and challenges. More specifically, when questions are taken up and when they are ignored or rejected without resolution is not something that Bledin & Rawlins explore. The explananda of the two models come apart. Moreover, the formalisms in the two models are also quite different. While Bledin & Rawlins introduce a goals stack, we introduce no such thing. Instead, we introduce an issue commitment set for each speaker such that it may be entirely private. We use decision problems to assign a measure, namely expected utility value (EUV), to rank questions in this set. Then, whether an asked question Q gets accepted depends on $EUV_B(Q)$, where B is the addressee, and how cooperative B is. If B is self-goal-oriented, then we interpret B's cooperatvity to be lower, requiring EUV_B to return a high value for a question Q for Q to be accepted. Note crucially that the procedure doesn't require decision problems to be public, which is a property that procedurally relevant decision problems possess in Bledin and Rawlins (2019).

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[12] See for instance Jaeger and Levy (2006); Barthel and Sauppe (2019).

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