

THE SEMANTICS OF RISING INTONATION IN INTERROGATIVES AND DECLARATIVES *

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Abstract

We analyze rising declaratives in English as modal expressions of epistemic uncertainty and argue that their question-like behavior is a secondary effect derived from maxims of rational conversation. In order to express the meaning with formal semantics, we combine Veltman's update semantics with the test operator with a simple semantics for polar questions.

1 Introduction

The semantics of intonation is notoriously difficult to capture formally and it has even been suggested that its meaning is metaphorical, non-denotational and non-compositional (a.o., Cook (2002), from the perspective of a cognitive psychologist) and fundamentally related to speaker's emotions rather than rational linguistic behavior. Since there is no general consensus on what the smallest meaningful intonational units are, it makes sense to focus on sentence melody as a carrier of information: In many languages it is used to express questions and even in languages which possess the means to render questions morphosyntactically (e.g., in English with subject-predicate inversion, or in French, with inversion or the '*est-ce que*' phrase), intonation can still "turn" statements into questions.¹ In general, *yes/no*-questions are usually reported to be associated with a rising contour, presence of a high pitch and/or a high boundary and experimental evidence shows that rising contours facilitate questions recognition. It is thus rather tempting (and, in fact, common in many typological and semantic studies) to identify rising intonation with question intonation. Undermining this view, however, are the results of corpus studies which show that there are questions (including many declarative questions) without rise and, crucially, rises which do not express questions. Moreover, rise in general is associated with a number of other meanings, such as checking whether the audience has understood what is being said, maintaining speaker-hearer solidarity, politeness, tentativeness, non-conduciveness, reservations and conciliatory attitude, friendliness, uncertainty, submissiveness and pleasantness. Gussenhoven (2004), similarly to Merin and Bartels (1997) and following Ohala (1984), considers many of these to be affective meanings of questioning but this view has been disputed, e.g., by van Alphen (2003)).

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¹In a large spoken corpus of American English free conversations, 'declarative questions' were counted more frequent than interrogative questions, i.e., questions expressed by means of syntactic inversion, and in French, inverted and *est-ce que*-questions are becoming rare in natural conversations (see Šafářová (in prep.) for details).

In this paper, we first shortly discuss existing semantic analyses of the rise (Pierrehumbert and Hirschberg (1990) and Gunlogson (2001)) and subsequently offer an alternative which can reconcile the conflicting empirical observations regarding its use in questions. Throughout, we make use of the results of the experiments by Šafářová and Swerts (2004) and Šafářová (in prep.) which unambiguously show that while some contours in AmE are more likely to be perceived as signaling questions – in particular those described by Gunlogson (2001) – they are neither sufficient nor necessary for this end. Combined with the observation that the contours can also appear on statements and that they are associated with a number of other meanings (though not, it seems, continuation), the idea that their semantics could be expressed solely in terms of questionhood is not tenable. At the same time, however, the semantic analysis has to account for the close association of rises with questions, and for the fact that their meaning is not ‘weaker’ than that of lexical-pragmatic features.

We suggest that these properties can be captured in a uniform way if we take the meaning of the final rise to be that of a modal expression of uncertainty. Formally, we express the meaning in terms of Veltman’s (Veltman (1996)) \diamond -operator, defined originally for expressions such as *it might be that* as introducing tests on the content of the common ground. We offer a simple update semantics for both the \diamond and the $?$ operators which is a combination of Veltman’s update semantics with a question semantics for propositional formulas and we represent rising declaratives as a $\diamond\phi$ -type of statements, rising interrogatives as $?\diamond\phi$ and falling interrogatives and indicatives as $?\phi$ and ϕ , respectively. One advantage of the proposal is that the relation between syntactic and semantic types is kept uniform, i.e., all syntactic declaratives are analyzed as statements. We can thus do away with the “hybrid” category of declarative questions, utterances with declarative syntax but the contextual behavior of questions. For example, a declarative question like ‘*Those are not all related languages* \uparrow ’ (where \uparrow symbolizes a final rise) is semantically analyzed as \diamond *those are not all related languages*, comparable to the statement ‘It might be that those are not all related languages’. We argue that the fact that this utterance would usually receive a reply from the addressee is due to the maxims of rational conversation which force the participants to address the issue under discussion and to make the strongest possible statement given their state of knowledge. A part of the analysis is a formalization of Grice’s maxims of quality, quantity and relation which also allows us to explain why statements of the kind $\diamond\phi$ and questions like $?\diamond\phi$ are not redundant in discourse, despite their semantics (according to which an update with $?\diamond\phi$ does not disconnect any worlds in the context and an update with $\diamond\phi$ does not change the context unless there are no worlds making ϕ true). We thus account pragmatically for what is sometimes considered a weak point of Veltman’s semantics for possibility. It follows straightforwardly from the analysis that rising declaratives are sometimes interpreted as indicating politeness, tentativeness and other affective states. We thus show that it is possible to address the semantics of intonation in a formal way without ignoring its ‘emotional’ aspects.

2 The Meaning of the End Rise in English

In this section, we sum up the properties of the ‘final rise’ relevant for a semantic account. Hence on, we will use the term ‘final rise’ as defined by Gunlogson (2001), i.e., as a nuclear contour which is non-falling and ends higher than the nuclear pitch accent. These

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contours have been found to be the best predictor of questioning (Šafářová and Swerts (2004), Šafářová (in prep.)). We will symbolize the final rise by \uparrow . For details on the empirical claims summarized below, see Chen and Gussenhoven (2003), Chen, Rietveld and Gussenhoven (2001), Fries (1964), Gunlogson (2001), Hirschberg (2000), Hirschberg and Ward (1995), McLemore (1991b), McLemore (1991a), Pierrehumbert (1980), Šafářová (in prep.) and Uldall (1964), among others.

1. \uparrow is possible but not necessary with inverted *yes/no*- and *wh*- questions - compare, for instance, the realization of the question ‘*Can I help you?*’ with a high rise in Fig. 1. and a fall in Fig. 2.

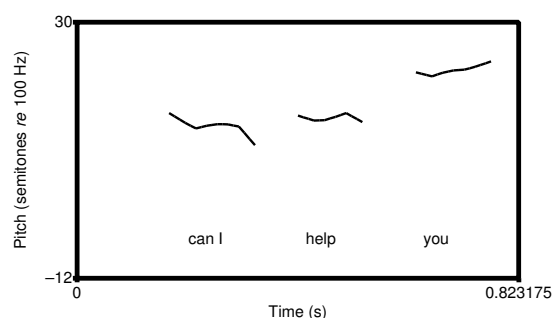


Figure 1.: A high-rising question ($H^*H-H\%$) with the nuclear pitch accent on ‘help’. [speaker L.M.]

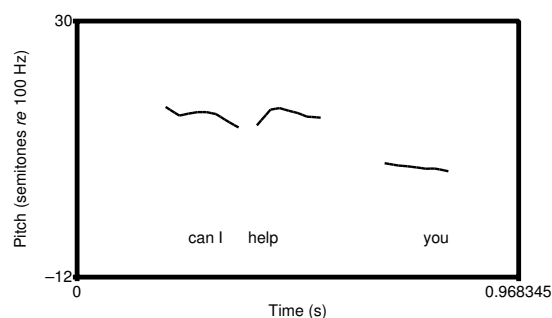


Figure 2.: A falling question ($H^*L-L\%$) with the nuclear pitch accent on ‘help’. [speaker L.M.]

2. \uparrow is possible on declaratives.

3. \uparrow -declaratives can receive different interpretations

- some of which do not result in a commitment from either the speaker or the addressee: **biased questions** where the addressee is often considered an expert on the issue, as in (1), and **try-out statements** where the speaker is stating a likely hypothesis, as in (2b):

- (1) *you’re leaving for vacation today* \uparrow
- (2)
 - a. Speaker A: *John has to leave early*
 - b. Speaker B: *he’ll miss the party then* \uparrow

- others result in speaker’s commitment: **checking statements** where the speaker conveys new information but wants to keep contact with the addressee, as in (3), or as **informative**

statements expressing polite/submissive/uncertain attitude, as in (3):

- (3) a. Speaker A: *I put a sign-up sheet over on the board*↑
 b. Speaker B: *it's for Dad's Day*↑

• are only used in case of a previous commitment from the addressee, as in **echo questions**, viz (4b).

- (4) a. Speaker A: *that copier is broken*
 b. Speaker B: *it is*↑ *thanks, I'll use a different one*

4. All these types of ↑-declaratives usually elicit a response from the addressee or give the impression of the response being welcome, i.e., they are question-like.

5. However, ↑-declaratives are not interchangeable with interrogative polar questions in context because they often convey a certain bias of the speaker, viz (5).²

- (5) [as an exam question]
 a. *is the empty set a member of itself?*
 b. *# the empty set is a member of itself*↑

6. ↑-utterances are considered to be more polite and friendly, but less confident.

7. ↑ is not associated with continuations.

8. The meaning of ↑ is not weaker than the lexical-pragmatic features of an utterance.

It would be desirable if the semantic theory of the final rise could account for all these facts, as well as the observation that declarative utterances that are 'hetero-cognitive' (e.g., give an account of the addressee's internal epistemic state) are question-like in the sense that they are responded to as if they were polar questions.

In the following subsections, we will shortly discuss two existing semantic proposals from the perspective of the empirical claims summarized above.

2.1 Pierrehumbert & Hirschberg (1990)

Pierrehumbert & Hirschberg suggest that particular tunes specify the relationship between the propositional content of the utterance over which they are employed and the mutual beliefs of the conversation participants. Their analysis is strictly compositional in that it ascribes meaning to all the (at that point) existing ToBI units, with some generalizations made about the meaning of the starred tones in pitch accents.

As for H*H-H%, sometimes referred to as the *high rise*, Pierrehumbert & Hirschberg suggest that it is used in questions which at the same time convey new information, as opposed to L*H-H%, which, according to them, is a question tune that does not convey new information (the L* tone indicating that the unit carrying the pitch accent is old news). McLemore (1991b) and McLemore (1991a), however, gives examples from her corpus of checking statements (i.e., statements conveying new information where the speaker uses the ↑ because she wants to maintain contact with her audience) with L*H-H%, as in (6).

²The # symbolizes a semantically anomalous sentence.

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She notes that “[the speakers] often use L*[with a high boundary] in the first intonational phrase of a monologue when other participants are assumed to have equal rights to the speaking floor” (p. 79). It is unclear how Pierrehumbert & Hirschberg’s description would apply to these contexts.

(6) *Y’all I was gonna tell (L*) y’all (H-H%)...*

As for L* L- H%, the authors take it to be signaling the continuation rise, an assumption that has not been supported by experimental evidence. They also associate the high boundary tone with a forward-looking function but the boundary tones do not appear to behave uniformly with respect to question identification. In sum, Pierrehumbert & Hirschberg’s proposal is interesting in its broad outlines - compositionality of the tone meaning, intonation as signaling relations to the mutual beliefs of discourse participants, etc., but the exact semantics remains rather informal and is not quite supported by the data. The idea of the H% tone having a ‘forward-looking function’ is not unintuitive, but it is not immediately obvious what the function does in a formal semantic or pragmatic sense. One could speculate that a tone with this function should not occur at points of (sub)-dialogue closure (in the sense in which it is discussed, e.g., by Muller and Prévot (2003) but there is not enough empirical evidence at this point to prove whether this proposal is sustainable or not. Finally, Pierrehumbert & Hirschberg’s system does not explain why ↑-declaratives convey a speaker bias and are not interchangeable with interrogatives.

2.2 Gunlogson (2001)

Gunlogson’s proposal is in the spirit of Pierrehumbert & Hirschberg in that it also takes the semantics of intonation to be expressing beliefs and mutual beliefs of participants about the truth of the conveyed proposition. Unlike the authors above, however, she is not concerned with the meaning of individual tones but with the contours of nuclear phrases as a whole. Disregarding interrogatives, Gunlogson focuses on the instances of final rises on syntactic declaratives and makes the following observations:

- Rising declaratives express a bias that is absent with the use of interrogatives; they cannot be used as neutral questions.
- Rising declaratives, like interrogatives, fail to commit the speaker to their content.
- Rising declaratives can only be used as questions in contexts where the addressee is already publicly committed to the proposition expressed (‘Contextual Bias Condition’).

As an illustration of the first point, consider the example in (7): while the interrogative in (7a) is acceptable in a context that has to be neutral, both the rising declarative in (7b) and the falling declarative in (7c) are excluded.

(7) [on a health insurance form]

- a. *Are you married?*
- b. *# You're married?*
- c. *# You're married.*

Gunlogson argues that the reason why (7b) and (7c) cannot be used in the context of a legal investigation is that they express a bias for the contained proposition being true.

As for the second and third observation, consider the exchange in (8):

- (8) a. Speaker A: *the king of France is bold*
- b. Speaker B: *France is a monarchy*↑

The rising declarative in (8b) clearly does not commit the speaker A to the truth of its content, rather, it questions a presupposition to which the speaker B has committed herself by using (8a).

In the semantics Gunlogson assigns to rises to account for these facts, her approach is closely related to that of Merin and Bartels (1997) who propose that rises ‘alienate choices to Alter’ (the addressee), while falls ‘appropriate choices to Ego’ (the speaker), and Steedman (2004) for whom the H% versus L% boundary tone distinction correlates with the ‘ownership’ of the content expressed. Specifically, Gunlogson implements the hypothesis that rising declaratives commit the addressee to the proposition expressed, while falling declaratives commit the speaker. Note that her description of the rise in terms of changing the commitment set of the addressee, however, does not really capture the observation made with respect to (8), that rising declarative can question a commitment already made by the addressee in the context. But even that condition is in general too strong; rising declarative questions are also used and recognized in contexts where the addressee is not publicly committed *to the truth* of the expressed proposition, but at most to *knowing whether* the proposition is true or not, given that he or she is regarded as an expert on the issue (9b).³

- (9) a. Speaker A: *he had a lot of real wacky ideas on big levels... he wanted a world power system, that you could tap into the air basically, and get power anywhere on earth...*
- b. Speaker B: *that's what the Tesla coil was about*↑
- c. Speaker A: *yeah, the problem was, that it interfered with, well, matter... I mean, it was not a clean broadcast system*

It is also not correct that rising declaratives always fail to commit the speaker to their content. As already noted above, they can be used as a politeness or checking device in situations where the speaker is informed with respect to an issue while the addressee is ignorant, as in (10), due to (Pierrehumbert 1980).

- (10) [to a receptionist] *hi, my name is Mark Liberman*↑

³Only a small subset of declarative questions is actually used after the addressee has explicitly committed himself/herself to the proposition expressed – namely, echoic questions – and their main function in the dialogue seems to be asking for additional evidence in support of the proposition expressed, rather than asking for a simple confirmation.

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One cannot reasonably claim for these cases that the addressee is either already committed to the truth of the propositions expressed by the speaker, or becomes so committed after they have been uttered (while the speaker does not). In fact, it turns out that rising declaratives can also be used without a prior or a subsequent commitment from either the speaker or the addressee: this is in case they are used as questions and the addressee chooses to be uncooperative and leaves them unanswered.

- (11) a. A: *he was going to uh, Peggy ... you remember Peggy White*↑
b. B: *yeah*

To illustrate, consider the example above: if speaker B would not reply, neither her nor speaker A would be committed to the proposition that ‘B remembers Peggy White’, while Gunlogson’s description of the context change potential of rising declaratives would predict that the proposition would be in B’s commitment set even without the confirmation in (11b).

This brings us to our final objection to Gunlogson’s approach, which is that the analysis does not explain why rising declaratives are usually responded to by the **addressee** as if they were questions. Gunlogson stipulates that uninformativeness with respect to the addressee is a necessary condition for an utterance to qualify as a polar question, but not that it is a *sufficient* condition. Given that the conditions on the use of rising declaratives are presumably a part of the rules of rational conversation exchange and thus mutual knowledge, Gunlogson’s analysis would predict a response from the addressee neither in case she disagrees with the proposition – because she would be inconsistent with herself –, nor if she agrees with it – because she would be agreeing with what she is already publicly committed to, which is superfluous.⁴ If we accept Gunlogson’s setup and make the natural assumption that the goal of the conversation is to exchange information and thus create shared commitments, it should make perfect sense that the **speaker** states whether she agrees or disagrees with the proposition. However, neither seems to be the case in conversation: ↑-declaratives usually elicit a confirmation or a disconfirmation from the addressee (be it at least in terms of a nod or a short backchannel) and are not commented upon by the speaker.

To sum up, Gunlogson’s proposal cannot account for a prevalent number of rising declarative usage types. Specifically, it cannot deal with examples where a rising declarative is used not because the addressee is committed to its content but rather because he or she is regarded as an expert on the issue, examples where it commits the speaker to its content, as well as those where neither the speaker nor the addressee become committed. Also, the approach does not offer a plausible explanation as to why rising declaratives in all of these cases tend to elicit a response from the addressee.

⁴As a matter of fact, Gunlogson would allow for the second case because for her, a sentence is informative if it is informative at least with respect to one commitment set. Note, however, that this has the unwanted consequence that a participant in a dialogue could repeat a sentence for as long as the addressee does not explicitly agree or disagree with it and still be informative.

2.3 Final Rise as a Modal Expression

2.3.1 General Remarks

In our proposal, we follow the approaches described above in that we take intonation use to reflect the status of propositions in the set of mutual beliefs/common ground in the conversation. We suggest that the crucial properties of \uparrow -declaratives can be captured in a uniform way if we take the meaning of the final rise to be that of a modal expression of epistemic uncertainty.⁵

The connection between final rises and uncertainty has been noted in several studies in the past (Uldall (1964), Chen and Gussenhoven (2003), Chen et al. (2001), Gussenhoven (2004)) and other attitudes usually associated with the rise like tentativeness, submissiveness or conciliatory attitude can be seen as secondary derivatives of ‘uncertainty’. In many contexts, expressing uncertainty may also sound more polite than a direct statement or a question, cmp. the examples below.

- (12) *Do you perhaps know...*
- (13) *Could you maybe tell us when you'll be arriving?*
- (14) *Maybe we could leave now.*
- (15) *I'm not sure but I think...*

These modal expressions help to preserve the addressee's face by giving him more space to refuse a request (e.g., for information) or an update of the mutual knowledge state. Uncertainty and lack of confidence was considered to be a secondary attitude accompanying the primary meaning of rising declaratives, typically taken to be ‘questionhood’.⁶ As already mentioned, we suggest that uncertainty is the primary meaning associated with the rises, and questioning is a derived pragmatic effect of using a rising declarative. In particular, both the attitudinal effect and the question-like interpretation of \uparrow -declaratives can be derived pragmatically, if we take the \uparrow to be a kind of an ‘intonational adverb’, comparable, for instance to *it might be that*. Together with the assumption that every statement is an answer to a (polar) question, this allows for an analysis that stays “true to form,” i.e., represents all declaratives as statements and all interrogatives as questions; it only follows from pragmatic reasoning about the content of the rising declarative that the addressee should comment on it.

⁵Interestingly, apart from the language internal data discussed in this section, there seems to be cross-linguistic evidence in support of the connection between questions and an expression of epistemic uncertainty (albeit of a morphological type): As noted by Palmer (1986), there are languages that use a ‘dubitative’ or ‘uncertainty’ morpheme to turn statements into questions: for example, in Hixkaryana, there are two ways to express non-past - certain and uncertain - and when the ‘non-past uncertain’ is used alone (without other modal particles), it expresses a question. What is relevant about these and other cases given by Palmer is that in various languages, questions appeared to be expressed with the help of a modal expression which, however, does not express interrogativity by itself or in general.

⁶Note here that questions in a conversation fulfill different *roles*. Some of them raise new conversation goals - we assume that those have to be raised explicitly and that it is crucial for their interpretation who raises them. Others *steer* the conversation in a direction which the speaker expects to be optimal with respect to reaching the conversation goal. Yet others can remain implicit (not uttered) because it is clear that an answer to them has to be found/grounded if the conversation goal is to be reached.

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2.3.2 The Proposal

In order to be able to translate both falling and rising statements and questions into the formal language, we combine Veltman's update semantics with a simple semantics for questions. Due to the semantics of the \Diamond , it is not possible to make direct use of the partition semantics for questions (Groenendijk and Stokhof (1996)) but we will make use of the idea that questions disconnect worlds in an information state. With respect to the language with the \Diamond operator, L_\Diamond , we stick to Veltman's original definition: we allow for stacking of the \Diamond operator and exclude its embedding under negation or in conjunction/disjunction. In $L_?$, we allow for the embedding of \Diamond under $?$ and exclude stacking and embedding of the $?$ operator. Hence, we can now have both statements with a \Diamond , $\Diamond\phi$, as well as questions, $?\Diamond\phi$, in other words (because we analyze the rise as \Diamond), we have both rising statements (declaratives), as well as rising questions (interrogatives).⁷

Definition 1. [Language]

Let us define the language L as the set of formulas $\phi ::= p | \neg\phi | \phi \wedge \psi | \phi \vee \psi$, where p ranges over atomic propositional formulas.

Then $L_\Diamond = L \cup \{\Diamond\phi | \phi \in L_\Diamond\}$, and $L_? = L_\Diamond \cup \{?\phi | \phi \in L_\Diamond\}$.

Definition 2. [Context]

Let W be the set of possible worlds and V a valuation function which in all $w \in W$ assigns to each propositional letter a truth value 0 or 1. Then a context σ is an equivalence relation on W , $\sigma \subseteq W \times W$, and $\text{dom}(\sigma)$, the domain of a context is the set of possible worlds in σ , $\text{dom}(\sigma) = \{w \in W | (w, w) \in \sigma\}$.

We write σ/X , $X \subseteq W$ for a restriction of a context, such that $\sigma/X = \{(w, w') \in \sigma | w, w' \in X\}$ and we will call $\sigma^0 = W \times W$ the state of complete ignorance and indifference where no statements have been made and no questions asked.

Definition 3. [Semantics]

- $\sigma[p] = \sigma / (\text{dom}(\sigma) \cap \{w \in W | V(p)(w) = 1\})$
- $\sigma[\neg\phi] = \sigma / (\text{dom}(\sigma) - \text{dom}(\sigma[\phi]))$
- $\sigma[\phi \wedge \psi] = \sigma / (\text{dom}(\sigma[\phi]) \cap \text{dom}(\sigma[\psi]))$
- $\sigma[\phi \vee \psi] = \sigma / (\text{dom}(\sigma[\phi]) \cup \text{dom}(\sigma[\psi]))$
- $\sigma[\Diamond\phi] \equiv \sigma$ if $\text{dom}(\sigma[\phi]) \neq \emptyset$ and \emptyset otherwise
- $\sigma[?\phi] = \{(w, w') \in \sigma | w \in \text{dom}(\sigma[\phi]) \text{ iff } w' \in \text{dom}(\sigma[\phi])\}$

Definition 4. [Common Ground and Information States]

The common ground, σ_{CG} is a context representing the shared beliefs of the speaker and the addressee in the discourse. σ_S is the speaker's information state and σ_A is the addressee's information state.

⁷Gerbrandy (1999) in his dissertation gives a formalization of Veltman's update semantics which allows for \Diamond being in the scope of negation. The interpretation of the formula we get with the semantics is, however, not intuitive: $\neg\Diamond\phi$ is interpreted as $\sigma - \sigma[\Diamond\phi]$, which is \emptyset if there is at least one ϕ world and σ otherwise. In natural language, however, a statement like 'It is not the case that he might come' would rather be interpreted as conveying the information that 'He is (certainly) not coming', i.e., as an update with $\neg\phi$ (or stronger, if possible in the formal language), not as a contradiction if it is not yet known whether ϕ or not.

One could try to give a fixed interpretation to $\neg\Diamond\phi$ formulas as being simply equal to $\neg\phi$, but such a system basically collapses to propositional logic. Thanks to Bernhard Schröder for the argument.

Definition 5. [Discourse and Updates]

A discourse Δ is a sequence of formulas $\phi_1, \dots, \phi_n \in L?$ where with each formula ϕ_i we associate a state of the common ground σ_{CG}^i , a state of speaker's belief state σ_S^i and a state of the addressee's belief state σ_A^i , such that $\forall i : \text{dom}(\sigma_S^i) \subseteq \text{dom}(\sigma_{CG}^i)$ and $\text{dom}(\sigma_A^i) \subseteq \text{dom}(\sigma_{CG}^i)$ and $\sigma_{CG}^i[\phi_i] = \sigma_{CG}^{i+1}$, $\sigma_S^i[\phi_i] = \sigma_S^{i+1}$ and $\sigma_A^i[\phi_i] = \sigma_A^{i+1}$. We write $\phi_1 \prec \phi_2$ for ϕ_1 precedes ϕ_2 in Δ .

With respect to answers, our aim is to have a definition which assigns to the question $? \phi$, ϕ and $\neg \phi$ as its possible answers (same for $? \neg \phi$) and to the question $? \diamond \phi$, $\diamond \phi$, ϕ and $\neg \phi$ as its possible answers. This effect does not come out straightforwardly with partition semantics of questions as in Groenendijk & Stokhof because, e.g., $? \diamond \phi$ does not introduce a partition based on its 'yes' and 'no' answers (one, elements of a partition cannot be empty, and two, there is no $\neg \diamond \phi$ in our language). Therefore, we propose a new definition of answerhood below.

Definition 6. [Syntactic Answerhood]

A syntactic answer to $? \phi$ is ϕ .

Definition 7. [Semantic Answerhood]

Let Υ be the set of **semantic answers** to $? \phi$ and ϕ its syntactic answer. Then $\phi \in \Upsilon$ and for any $\psi \in L_{\diamond}$, $\psi \in \Upsilon$ iff $\neg \exists v \in \Upsilon, v \in L : \text{dom}(\sigma^0[\psi]) \subset \text{dom}(\sigma^0[v])$ and $\exists v \in \Upsilon, \sigma^0[\psi][v] = \emptyset$.

Take the simple case of a question like $?p$. Then p is its answer syntactically and $\neg p$ is its answer because $\sigma^0[\neg p][p] = \emptyset$. Take $? \diamond p$ as another example. Then $\diamond p$ is its syntactic answer. Next, $\neg p$ is its answer because $\sigma^0[\neg p][\diamond p] = \emptyset$. Finally, p is its answer because $\sigma^0[p][\neg p] = \emptyset$. Furthermore, the condition $\neg \exists v \in \Upsilon, \text{dom}(\sigma^0[\psi]) \subset \text{dom}(\sigma^0[v])$ has as its goal to exclude the possibility that $\neg p \wedge q$ would become an answer to $?p$ (because $\sigma^0[\neg p \wedge q][p] = \emptyset$) and then $\neg q$ would become an answer because $\sigma^0[\neg q][\neg p \wedge q] = \emptyset$ and so on, potentially infinitely. Also, the condition excludes contradictions as possible answers. An update of σ^0 (the state of complete ignorance) with a contradiction gives \emptyset , which would be a proper subset of the state of ignorance updated with, e.g., the syntactic answer to the question. Note that if the question itself concerns a contradiction, this is not the case; e.g., a question $?p \wedge \neg p$ can have anything as its answer, including contradictions, because its syntactic answer is $p \wedge \neg p$.

Given this definition, the question *Is Sarkozy a clever man?* (with **falling** intonation) would have in its set of possible answers only (16a) and (16b), while the question *Is Sarkozy a clever man?*⁸ (with **rising** intonation) would have all (16a), (16b) and (16c) as its possible answers.⁸

- (16) a. *Yes. (Sarkozy is a clever man).*
 b. *No. (Sarkozy is not a clever man).*
 c. *Maybe. (Sarkozy might be a clever man).*

Based on Grice's principles of rational conversation, we define four maxims which will restrict the number of eligible discourses, namely Quality, Relation, Quantity (1) and

⁸To be precise, given the analysis of rises here, it can also receive (16a) and (16b) with rising intonation as an answer.

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Quantity (2). Note that one of the goals of the analysis is to explain why both \diamond statements and \diamond questions are nonredundant. Existing formulations of redundant conversation moves (e.g., Groenendijk (1999)) assume that a statement is redundant if updating with it does not change the content of the common ground. Similarly, a question would be redundant if an answer to it would already be known, which technically translates into ‘not disconnecting any possible worlds’ or ‘not creating a (non-empty) partition’ of the common ground. Under this view, both \diamond statements and \diamond questions come out as being redundant, which is an undesirable effect. Therefore, we propose a different definition of redundant conversation moves, formulated in Quantity (2).

Definition 8. [Maxims of Conversation]

- **Quality:** A discourse Δ conforms to Quality iff for every statement $\phi_i \in \Delta$, $\sigma_S^i[\phi_i] = \sigma_S^i$.
- **Relation:** A discourse Δ conforms to Relation iff for every statement $\phi_i \in \Delta$, ϕ_i is a semantic answer to the most recent unresolved question. $? \phi_i$ is unresolved in σ_{CG}^i iff $\exists w, w'$ such that $w \in \text{dom}(\sigma_{CG}^i)$ and $w' \in \text{dom}(\sigma_{CG}^i)$ and $(w, w') \notin \sigma^0[? \phi_i]$.
- **Quantity (1):** A discourse Δ conforms to Quantity (1) iff for every statement $\phi_i \in \Delta$, there is no stronger statement given σ_S^i , speaker’s knowledge at that point in the conversation. ϕ is stronger than ψ iff $\text{dom}(\sigma^0[\phi]) \subseteq \text{dom}(\sigma^0[\psi])$.
- **Quantity (2):** A discourse Δ conforms to Quantity (2) iff for every $\phi_i \in \Delta$, ϕ_i is not redundant in σ_{CG}^i . A question $? \phi_i$ is redundant with respect to σ_{CG}^i if all its semantic answers are redundant in σ_{CG}^i . A statement ϕ_i is redundant with respect to σ_{CG}^i iff with respect to $\phi_i^{SUB} \in L$, ϕ_i^{SUB} being the largest propositional subformula of ϕ_i , $\sigma_S^i[\neg \phi_i^{SUB}] = \sigma_{CG}^i[\neg \phi_i^{SUB}]$.

By Quantity (2), questions like $? \diamond \phi$ are only redundant if it is already known whether ϕ or $\neg \phi$. A statement $\diamond \phi$ is not redundant iff the speaker’s information state updated with $\neg \phi$, would be a proper subset of the common ground updated with $\neg \phi$, i.e., $\sigma_S^i[\neg \phi] \subset \sigma_{CG}^i[\neg \phi]$. This will be the case if there are less $\neg \phi$ worlds in σ_S^i than in σ_{CG}^i , i.e., if the speaker believes $\neg \phi$ to be less likely.

To see how the proposed theory works in practice, in the next section of this paper, we return to the points (1)-(8) from section 2.

3 Discussion

It is easy to express the observation that inverted *yes/no*-interrogatives can sometimes appear with a rise. If they do, we represent them as $? \diamond \phi$ and correctly predict that they will be perceived as more polite (but possibly also more hesitant) than the falling $? \phi$: they allow for the weak answer $\diamond \phi$, while their falling counterparts require a stronger commitment from the addressee.⁹

Similarly, rise on a declarative, $\diamond \phi$, is interpreted as a weaker type of statement than a falling declarative ϕ . Using it does not result directly in any commitment (either from the speaker or from the addressee), because an update with a test does not eliminate worlds from the common ground. However, by Quantity (2), the addressee can derive that there is at least one world in the common ground in which $\neg \phi$ holds and in which the speaker

⁹Given the semantics we use, we have nothing to say about *wh*-question.

does not believe. In a common ground in which there is only *one* $\neg\phi$ world, uttering $\diamond\phi$ will thus effectively result in an update with ϕ ! We can thus also account for cases in which uttering a rising declarative results in a commitment by the speaker. As for echo questions, the present setup predicts that using a rising declarative $\diamond\phi$ directly after ϕ has been uttered by the other participant is redundant. The fact that the speaker uses it nevertheless suggests that for some reason, the update of the common ground with ϕ was not successful and/or the common ground has to be revised. This corresponds to our intuition that echo questions involve disagreement between the participants and can be interpreted as requests for additional information or at least confirmation. Accounting for this process exactly, however, requires a more fine-grained machinery than the one proposed in the present paper.

In general, we assume that uttering a possibility statement, i.e., a \diamond -statement, accommodates a question to which it is a syntactic answer, i.e., $?\diamond p$, which has $\diamond p$, p and $\neg p$ among its answers. In a rational conversation, participants cooperate on finding the strongest possible answers to questions that have been raised (whether overtly or accommodated). Therefore, if a $?\diamond p$ question has been raised and there is a participant who knows that either p or $\neg p$ is the case, she has to say so. Thus, a rising declarative (a \diamond -type of statement), will frequently be followed by a ‘response’. Crucially, this response is not an answer to the rising declarative but to the question *accommodated due to the use* of the rising declarative.

The analysis can easily model the fact that rising declaratives are not interchangeable with questions: after all they are assertions, which express a bias also in contexts in which the ratio of worlds making them true and worlds making them false should remain 1:1. For example, used as an exam question, a rising declarative *the empty set is a subset of itself* \uparrow would swing the odds of the proposition ‘the empty set is a subset of itself’ being true for its favor in a common ground in which the amount of $\emptyset \not\subset \emptyset$ -worlds is supposed to be equal to the amount of $\emptyset \subset \emptyset$ -worlds.

Similarly to rising *yes/no*-questions, also rising declaratives come out as being more polite than their falling counterparts. If the speaker updates the common ground with a falling declarative ϕ and the addressee believes $\neg\phi$ to be true, the participants are in an open disagreement and a correction of the common ground may be needed. If, on the other hand, the speaker uses a rising declarative $\diamond\phi$, she generally does not eliminate all $\diamond\neg\phi$ worlds (unless there is only one) and the addressee can still utter the stronger statement $\neg\phi$, if she believes it to be true, without overtly disagreeing.

The proposal does not predict any link between \uparrow and continuations, which is correct, given that in English, empirical studies suggest that different kinds of intonational patterns are involved (see (Šafářová in prep.) and the references cited there). Note also that the meaning of the rise is here treated on the same level as the meaning of the lexical features of the utterance and interacts with them; intonation is not semantically “weaker”.

As a final remark, let us stress that in our proposal, the \uparrow is **not** exactly synonymous with a particular lexical adverb and all the translations of the final rise with a lexical expression should be understood very loosely. The syntactic and semantic behavior of lexical adverbial expressions and corresponding adjectival phrases is rather complicated (viz. a.o., Cinque (1999), Nilsen (2003)): for example, the adverb *possibly* appears to be excluded from some (but not all) interrogatives, while its adjectival counterpart *it is possible that* is

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not. Also, it is generally assumed that there is a syntactic and presumably also semantic difference between *it might be that*, *maybe*, *possibly*, *perhaps*, etc. In principle, we do not exclude the option of formalizing the meaning of one of these operators with Veltman's test diamond (the semantics we make use of does not exclude multiple presence of the epistemic operator which will be represent with a \diamond , so the option of combining intonational and lexical expressions exists). At least '*maybe*', however, seems to function differently from the rise, as show by the following dialogue:

- (17) a. A: *I lost my ring*
 b. B: *did you leave it in the bathroom?*
 c. B': *maybe you left in the bathroom*
 d. B'': *you left in the bathroom* \uparrow

The reply (17d) patterns with the reply in (17b) in that a response by speaker A is expected. The relevant difference seems to be that in (17b) and (17d), but not necessarily in (17c), the speaker A is assumed to be knowledgeable with respect to the content of the utterance. However, this example cannot be handled by the formalization proposed below, because we lack the machinery to express propositions of the type 'A knows that...'.¹⁰

4 Summary and Future Work

The proposal in this paper can be summarized as $\uparrow = \diamond$. While, in our view, it can model a number of facts about the use of rising intonation in American English, the formal language is quite simple and cannot express *wh*-questions and propositions of the type 'A knows that' or the effect of utterances like '*I don't know*' on the common ground. Employing a knowledge operator could possibly also help to address the fact that not only rising declaratives, but also falling declaratives are often responded to by the addressee if they concern an issue on which she is an expert.

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¹⁰Thanks to David Ahn for bringing this example to my attention.

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