

# Testing formal pragmatics of questions through their ignorance inferences\*

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## Abstract

Questions are well-studied in semantics, including from a psycholinguistics perspective. They also play a key role in pragmatics through *questions under discussions*, which are known to affect a wide range of phenomena (e.g., focus, implicatures). The pragmatics of questions themselves however is largely understudied, with very few theoretical proposals and only a handful of experimental studies. Pragmatics studies how speakers choose an utterance over possible competitors, and how listeners can draw complex inferences by reconstructing the speaker’s reasoning leading to this choice. While we have a good understanding of the factors at play when a speaker utters a declarative sentence, much less is known about questions. The goal of this paper is to test two proposals extending Grice’s Maxims to questions: van Rooij’s entropy as a measure of question utility, and Groenendijk and Roelofsen’s inquisitive pragmatics. The two theories make opposite predictions regarding the choice between polar and wh-questions in ignorance and partial knowledge situations, and therefore the implicatures they give rise to regarding the questioner’s knowledge. The results of two experiments corroborate the predictions of van Rooij’s proposal. In passing, we establish that the cornering effect of negative alternative questions (Biezma 2009) is independent from their ignorance requirements.

## 1 Introduction

### 1.1 Questions in pragmatics, and pragmatics of questions

Since the work of Roberts (1996), questions have played a crucial role in pragmatics via *questions under discussion*—a theoretical construct describing how any sentence should be understood as addressing an (often implicit) question. This approach has been extremely fruitful and has been applied to a wide variety of topics in formal pragmatics (see Benz and Jasinskaja, 2017 for a review). However, much less has been said on the pragmatics of questions themselves. While we have a good understanding of the principles guiding speakers’ choice of a declarative utterance (dating back at least to Grice, 1967), much less is known regarding questions: How does a speaker’s intentions affect their choice of a question? How does the interpretation of a given question vary with context?

Relevant work includes a few studies on contextual dependency of question interpretation (Ginzburg, 1996; Aloni, 2005; Potts, 2012), a very rich literature on so-called *biased questions*, i.e. specific forms of questions which tend to convey a speaker’s bias towards certain answers (e.g., negative questions; Romero and Han, 2004, a.o., negative alternative questions; Biezma, 2009; Biezma and Rawlins, 2012; Beltrama et al., 2018, discourse particles in questions), and—what will interest us here—a few proposals for a formal theory of how speakers choose particular questions to achieve specific goals.

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## 1.2 Existing proposals and their predictions

One of the earliest proposals is [van Rooy \(2003\)](#), who defines a measure of utility for questions given a speaker’s goal, formalizing ideas from previous work (in particular [Ginzburg, 1995](#) and [Krifka, 1995](#)). Under the assumption that the speaker is only trying to learn the truth, this measure boils down to the expected informativity of answers to the question, i.e. the question’s entropy ([van Rooy, 2004](#)), as defined in (1) for a question yielding the partition  $Q$ .<sup>1</sup>

$$(1) \quad U(Q) = \sum_{p \in Q} \Pr(p) \times (-\log_2(\Pr(p))) = E(Q)$$

The speaker then selects the question which maximizes entropy, and this turns out to be the most general question available, formalizing an intuition of [Krifka \(1995\)](#).

An alternative proposal has been sketched in [Groenendijk and Roelofsen \(2009\)](#), henceforth: G&R), building on inquisitive semantics. Without going too far into details, their idea is that questioners should favor questions which have a higher chance of being answered, all else being equal. This is essentially the opposite of [van Rooy’s](#) proposal, as it gives higher values to questions with less informative answers (i.e. answers the addressee is more likely to know).

A direct way to tease apart these two accounts is to look at the competition between polar and wh-questions. Taking the example of the 2018 soccer world cup final brackets, we can consider two possible situation: a (partial) knowledge situation, where the speaker knows which two countries made it to the final, but not which of them won, and a (full) ignorance situation where the speaker has no idea which of the 8 countries that reached quarter finals could have won (and considers them equally likely to win). Now let’s assume that the goal of the speaker is to find out who won the world cup.

Let’s first look at [van Rooy’s](#) theory. In the knowledge situation, there are only two options (France and Croatia). The two questions “Did France win?” and “Who won?” have the same entropy, since the relevant probability measure is the questioner’s internal beliefs (the questionee is assumed to be knowledgeable), and for the speaker the two questions are semantically equivalent. All else being equal, the two questions should therefore be equally good (at this point, other factors such as utterance length or complexity should come into play). For the ignorant speaker, the situation is different. The polar question has much lower entropy than the who-question (about 0.5 versus 3), so the wh-question should be preferred. In short, [van Rooij](#) predicts the wh-question to be acceptable in both ignorance and knowledge situations, while the polar question should only be good in the knowledge situation (unless we assume a different speaker goal). From the addressee’s point of view, hearing a polar question would suggest that the questioner is already quite knowledgeable, whereas hearing a wh-question does not indicate anything about the questioner’s knowledge.

Turning to G&R’s inquisitive pragmatics, we might need to fill in some gaps first. They propose that the least inquisitive question should be preferred, but it’s unclear against what information state this should be measured. Considering the whole logical space, the wh-question asymmetrically entails the polar question, so it should never be used. Considering the speaker’s information, the two questions become equivalent in the knowledge situation, so the polar question would only be preferred in the ignorance situation. However, none of these options make much sense given the motivation for this constraint: the goal is to make sure the addressee can answer the question. What should matter then, is what the speaker knows of her addressee’s information state. If the participants in the conversation know nothing about each other besides what has been said so far, this is just the common ground. If the common ground does not

<sup>1</sup>It is not essential for the analysis to assume that questions denote partitions ([van Rooy, 2004](#) for details).

contain the speaker’s knowledge, the speaker should contribute this knowledge before asking a question. We can therefore assume that in the knowledge situation, the common ground already entails that France or Croatia won, and so the two questions are equally inquisitive. Conversely, the common ground cannot be more informative than the speaker’s knowledge, so in the ignorance situation, the wh-question is strictly more inquisitive than the polar question. In short, assuming that participants have been cooperative so far, measuring inquisitiveness against the common ground amounts to measuring it against the questioner’s information state, so it predicts that polar questions should be preferred in the ignorance situation only. Finally, if the speaker knows that her addressee is fully informed, none of the questions will be inquisitive in the addressee’s information state, therefore no preference is predicted (in this case, one would need to complement the proposal with an independent maxim). In short, inquisitive pragmatics predicts either no preference between the two questions, or a preference for polar questions in ignorance situations. From the hearer’s perspective, wh-questions would suggest that the speaker is quite knowledgeable already, while polar questions do not indicate anything about the questioner’s knowledge as they are always optimal.

## 2 Experiment 1

### 2.1 Goal and Design

The goal of this first experiment was to test whether questions do indeed give rise to ignorance inferences, and to compare the predictions of the different theories. We tested this straightforwardly with an inference task where participants had to evaluate how much a speaker knows about a given situation given the question they asked, as illustrated in Figure 1.

*Dave wants to get an exotic pet. He went to an exotic pet store and there were only snakes and iguanas. Afterwards he called his friend Barbara, and Barbara asked him...*

**Barbara:** “What animal did you get?”

Would you conclude that Barbara knows that there were only snakes and iguanas in the exotic pet store?

Definitely not  1  2  3  4  5  Definitely yes

Figure 1: Example of an item from Experiment 1 with a wh-question.

More specifically, each item introduced a context which established a disjunctive restriction on some predicate (in this case, Dave either got a snake or an iguana), and a character asked a question. Participants then had to judge whether the questioner was aware of the restriction on a scale from “definitely not” to “definitely yes”. We tested the three constructions of interest in (2a-c): wh-questions, plain polar questions, and negative alternative questions (NAQ). The latter has been shown to have specific pragmatic effects (Bolinger, 1978), for which different explanations have been put forward, predicting different patterns of interaction with ignorance effects (we come back to this in the discussion).

There are three possible effects for a given question. It can either convey speaker knowledge, convey speaker ignorance, or not convey anything regarding the speaker’s knowledge state. We therefore used three baselines: the alternative question in (2d) presupposes knowledge of the

disjunction so it offers a knowledge baseline, the polar question in (2e) is fully resolved by the disjunction, so it can only be used if the questioner is ignorant, and the unrelated question in (2f) does not say anything about the questioner’s knowledge so it allows us to probe the prior knowledge participants would attribute in a given scenario.

- (2) a. WH: “Who won the finals?”  
 b. POLAR: “Did France win the finals?”  
 c. NAQ: “Did France win the finals or not?”  
 d. ALTERNATIVE: “Did France or Croatia win the finals?” (knowledge baseline)  
 e. RESOLVED polar: “Did Belgium win the finals?” (ignorance baseline)  
 f. UNRELATED: “Was any player wounded during the finals?” (prior baseline)

## 2.2 Methods and Materials

The survey was built using a latin square design with question type as a within-subject and within-item factor. We used 3 repetitions per level, hence created 18 contexts.<sup>2</sup> We also included two training items at the beginning of the survey and four fillers.

71 participants were recruited on Amazon Mechanical Turk (age range: 23–62). The survey took about 10min and was paid \$1.40. One non-native speaker was removed from the analysis, as well as 7 participants whose error rate on fillers was more than one standard deviation above the mean (threshold: 53%).

## 2.3 Results

The results for each construction are presented in Figure 2. The control items behave as expected: the ALTERNATIVE question clearly conveys knowledge while the RESOLVED polar question clearly conveys ignorance. The UNRELATED question indicates that participants tend to assume that the speaker is ignorant by default.

The results were analysed with a proportional-odds mixed-effects model (using package `ordinal` in R) with maximal by-item and by-subject random-effects structure (Barr et al., 2013). Question type was treatment-coded with the UNRELATED question as baseline. We calculated the 95% confidence interval for each parameter, as indicated in Table 1. The analysis confirms what can be seen on the graph: the WH questions are virtually indistinguishable from the UNRELATED control, the polar questions and NAQ give rise to significantly stronger knowledge inferences, albeit less than the alternative questions. Furthermore, the results confirm that there is no difference whatsoever between polar questions and NAQ with respects to knowledge/ignorance inferences.<sup>3</sup>

## 2.4 Discussion

The results indicate that WH-questions do not in fact convey ignorance, while the polar questions and NAQ do suggest some degree of knowledge, albeit not as much as the alternative questions which presuppose such knowledge is common ground. At first glance, this is support for van

<sup>2</sup>All materials, including a list of all contexts, are available at <https://semanticsarchive.net/Archive/GM1NGI2Z/Zhao-Cremers-QuestPrag.html>, together with anonymized data and analysis scripts.

<sup>3</sup>On a suggestion of Manuel Križ, we tested possible differences between wh-questions with *which*-phrases and with plain wh-word as a posthoc analysis. Nevertheless, a proportional-odds mixed model on WH-questions with type of wh-phrase as a fixed and by-subject random effect revealed no significant difference ( $\chi^2(1) = 1.6, p = .21$ ).

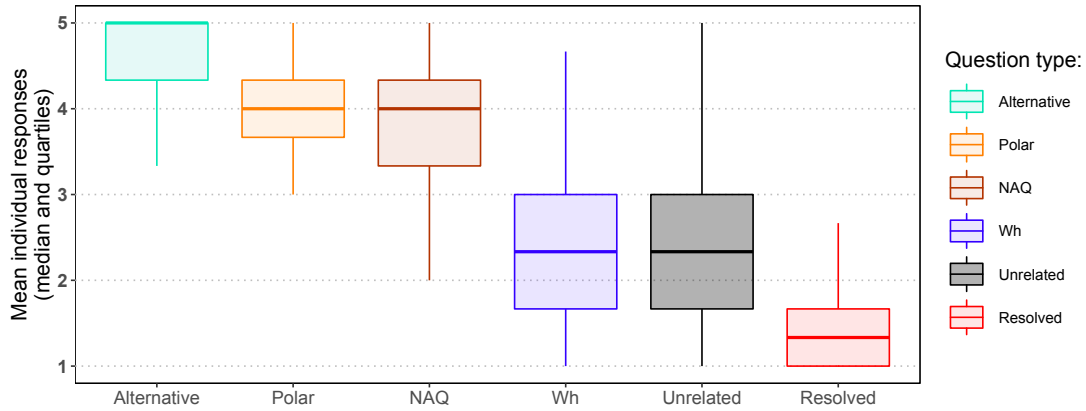


Figure 2: Results from Experiment 1. The ALTERNATIVE and RESOLVED polar questions provide the baseline for knowledge and ignorance respectively. The UNRELATED question serves to probe participants’ prior on knowledgeability of the speaker when the question offers no indication.

Parameter	$\beta$	95% CI
RESOLVED	-2.1	[-3.1, -1.2]
WH	-0.1	[-0.8, 0.6]
POLAR	2.8	[2.0, 3.5]
NAQ	2.8	[2.0, 3.6]
ALTERNATIVE	5.9	[4.5, 7.3]

Table 1: Estimated parameters and their 95% confidence interval for Experiment 1.

Rooy contra G&R, but before going any further into our discussion of theoretical implications, we want to rule out low-level explanations for the results.

An anonymous reviewer points out that implicit restriction on the domain of the wh-phrases may have affected the results. After all, with explicit restrictors, wh-questions can either convey ignorance (“Which of the 32 competing countries won the world cup?”) or knowledge (“Which of France and Croatia won the finals?”), so leaving the restriction implicit could lead to uncontrolled biases. Note however that in van Rooij’s theory, the probability measure used for entropy is the speaker’s subjective probability, so it isn’t be affected by the explicit restrictor as long as it contains all the answers that the speaker considers possible (answers known to be false do not contribute any entropy). In particular, it is not possible to explain the absence of ignorance inference from wh-questions as covert domain restriction to the two disjuncts: if the speaker is knowledgeable, assuming a smaller domain does not increase the entropy of the wh-question. If the question with an unrestricted domain was infelicitous, the overt “which of A and B” would also be.<sup>4</sup>

<sup>4</sup>The opposite effects of the two restrictors are presumably independent from entropy, although one can be captured by van Rooij’s account. Making overt a smaller domain would reduce entropy, on top of presumably leading to a presupposition failure (assuming the question has an existential presupposition). The entropy account therefore predicts that the questioner considers that the true answer must be in the restrictor (hence the knowledge inference from “which of A and B”), but this is arguably a presupposition to being with. The account does not explain why using a larger domain would lead to an ignorance inference however. The explication seems to be an implicature that each member of the restrictor may be the true answer. Cremers et al. (2019b) discuss

One could imagine that the WH-question fails to give rise to any implicatures simply because participants fail to take into account its polar alternative. Indeed, Cremers et al. (2019a) observed that ignorance inferences from superlative modified numerals were missing in an inference task directly probing them, but were properly detected in an acceptability judgment task. They attribute this effect to the difficulty of the inference task, which led participants to ignore alternatives with a comparative modifier. One reason to suspect that such an effect could be at play here is the asymmetry between the knowledge inference of the polar question and NAQ on the one hand, and the lack of ignorance inference from the wh-questions. Indeed, assuming that participants were fully rational, even if the wh-question does not convey ignorance on its own, the fact that the speaker did not use a polar question should increase the posterior probability for ignorance.<sup>5</sup> We therefore conclude that participants were not fully rational in their inference patterns.

To address this potential limitation of Experiment 1, we ran a second experiment aiming to replicate the results using an acceptability judgment task.

## 3 Experiment 2

### 3.1 Goal and Design

The goal of this experiment was to replicate the results of Experiment 1 using a different design, namely an acceptability judgment task. The idea is to now explicitly include information about the questioner’s knowledge and probe the acceptability of the various questions given this information. The difference between situations in which the questioner is knowledgeable and situations in which they are not indicates whether the question imposes any constraint on the questioner’s internal state. More specifically, if a question requires speaker ignorance, it should be less natural in a situation where the questioner has partial knowledge. Conversely, a question which requires partial knowledge would be less natural when the speaker is fully ignorant.

### 3.2 Methods and Materials

We created two versions of each context in Experiment 1: one in which the questioner was described as aware of the disjunctive state of affairs, and one in which the information corresponding to the disjunctions was omitted entirely and the questioner was described as fully ignorant. The participants’ task was to evaluate whether the question was natural given what they know of the situation and the questioner’s knowledge state. Figure 3 presents an example of ignorance item.

We tested the same questions from Experiment 1 minus alternative questions. Indeed, in an ignorance situation, an alternative question would lead to a presupposition failure. Since

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the case of questions embedded under *wonder*, and show that this ignorance implicature is sensitive to the form of the restrictor (it is stronger when the restrictor is an explicit conjunction, and possibly when it contains a numeral).

<sup>5</sup>Specifically, assuming that participants apply Bayesian reasoning and that polar questions increase the posterior probability for knowledge (i.e.  $P(\text{knowledge}|\text{polar}) > P(\text{knowledge})$ ), it follows that:

$$P(\text{knowledge}|\neg\text{polar}) = \frac{P(\text{knowledge}) - P(\text{knowledge}|\text{polar})P(\text{polar})}{1 - P(\text{polar})} < P(\text{knowledge})$$

Note that to get close to equality, we would need to assume either that the knowledge inference from polar questions is very small ( $P(\text{knowledge}) \approx P(\text{knowledge}|\text{polar})$ ), in clear contradiction with our results, or that polar questions are unexpected ( $P(\text{polar}) \ll 1$ ), which seems unreasonable, especially when these questions appeared as frequently as wh-questions in our design.

One day, Tony is visiting his friend Betty, who just got a fancy coffee machine.  
Betty doesn't know what coffee Tony likes. Before making coffee, she asks...

**Betty:** "Would you like an espresso?"

How natural is Betty's question in this context?

Odd  1  2  3  4  5  Natural

Figure 3: Sample item from Experiment 2 with a wh-question and a fully ignorant questioner.

this infelicity is presumably stronger than infelicities due to violations of pragmatic constraints, we considered that it risked pushing participants to accept all other questions even when they should have been pragmatically odd (or at least reduce the resolution of our experimental paradigm). We therefore decided to do without an upper bound on knowledge requirements, but kept felicitous alternative questions as true fillers in the experiment (to ensure that they remain salient as alternatives to other questions).

We now had two experimental factors: question type (5 levels)  $\times$  questioner knowledge (2 levels). We reduced the number of repetitions per item to two, and created two new contexts, for a total of 20. The design was again a latin square with both factors within-item and within subject. Each participant only saw a given context under one knowledge condition to avoid potential confusion about what the questioner actually knows.

77 participants were recruited on Amazon Mechanical Turk (age range: 20–65). The survey took about 10min and was paid \$1.40. One non-native speaker was removed from the analysis, as well as 7 participants whose error rate on fillers was more than one standard deviation above the mean (threshold: 53%).

### 3.3 Results

The results for each construction are presented in Figure 4. Control items behave as expected: the UNRELATED question is as acceptable under ignorance as it is under partial knowledge, while the RESOLVED question is clearly degraded under partial knowledge.

The results were analysed with a proportional-odds mixed-effects model (using package `ordinal` in R) with by-item and by-subject random intercepts and slopes for the two main effects, but not for the interaction. Both factors were treatment-coded with UNRELATED and IGNORANCE as baselines. We calculated the 95% confidence interval for each parameter, as indicated in Table 2.

The results overall confirm the first conclusion from Experiment 1: the polar questions and NAQ are much less natural when the questioner is fully ignorant (i.e. they require partial knowledge). In contrast with Experiment 1, WH-questions now seem to be slightly better with ignorance (the effect doesn't reach significance though:  $p = .07$ ).<sup>6</sup>

A posthoc analysis also revealed that NAQs are overall less natural than polar questions ( $\chi^2(1) = 21, p < .001$ )—possibly reflecting the cornering effect—, but that this effect is independent of the questioner knowledge requirement imposed by both questions (no interaction with KNOWLEDGE;  $\chi^2(1) = .05, p = .82$ ).

<sup>6</sup>This time again, there was no difference between which-phrases and plain wh-words ( $\chi^2(1) = 1.1, p = .29$ ).



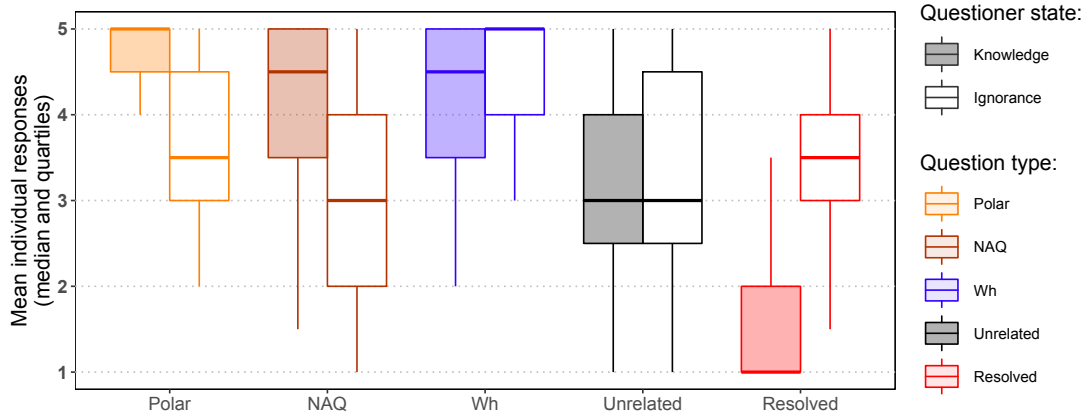


Figure 4: Results from Experiment 2. The UNRELATED question offers a baseline for a question the acceptability of which does not depend on the questioner’s knowledge. The RESOLVED polar questions indicates a maximal contrast, as it’s completely resolved by the disjunctive knowledge.

Parameter	$\beta$	95% CI
RESOLVED	-1.4	[-2.2, -0.5]
WH	2.2	[1.4, 3.1]
POLAR	1.6	[0.7, 2.5]
NAQ	0.5	[-0.3, 1.3]
KNOWLEDGE	-0.1	[-0.7, 0.4]
RESOLVED $\times$ KNOWLEDGE	-3.5	[-4.2, -2.7]
WH $\times$ KNOWLEDGE	-0.7	[-1.4, 0.06]
POLAR $\times$ KNOWLEDGE	2.1	[1.4, 2.8]
NAQ $\times$ KNOWLEDGE	2.0	[1.3, 2.6]

Table 2: Estimated parameters and their 95% confidence interval for Experiment 2.

### 3.4 Discussion

The second experiment closely replicates the results of Experiment 1. Unlike Cremers et al. (2019a), we did not observe a significant task effect on ignorance inferences. We did however observe that the task was easier for participants, as the mean error rate after exclusion was 7%, down from 19%, and a trend for a small ignorance inference with wh-questions. This is still compatible with van Rooij’s predictions that wh-questions are compatible with both ignorance and knowledge, but compete with equivalent polar questions in knowledge situations, slightly reducing their acceptability.

## 4 General discussion

Our results reveal that polar questions are more acceptable when the speaker has partial knowledge, and participants infer knowledge from them, while wh-questions do not convey knowledge and do not seem to convey ignorance either (although there is a small non-significant trend in this direction). Overall these results conform with the predictions of van Rooij (2003).



While some predictions of G&R seem clearly wrong (e.g., that wh-questions should convey partial knowledge), some ideas make intuitive sense and could easily be implemented in van Rooij’s framework. The main intuition is that questioners should take into account the possibility that their addressee doesn’t necessarily have enough information to answer their questions, and that is why they should not always aim for the question with the most informative answers. Concretely, we would replace the probability that an answer is true with the probability that it is true *and* known to the addressee. However, as appealing as it may be, there may be a good reason why we don’t see evidence for this idea in the data: Once we take partial answers into consideration, stronger (more inquisitive) questions may in fact always provide more information than less inquisitive ones.<sup>7</sup>

Finally, an independent contribution of our study is to further demonstrate that the cornering effect of NAQs is orthogonal to their knowledge implicatures. This is new support for Beltrama et al. (2018), who argue against Biezma and Rawlins’s (2017) bundling explanation. Biezma and Rawlins assume that the NAQ bundles together alternatives that the plain polar question leaves open. Framed in van Rooy’s (2003) terms, this would mean that it has a lower entropy (since it does not distinguish between multiple alternatives) and should therefore be more sensitive to ignorance than the polar question as it has even lower utility compared to the wh-question. This would translate into stronger knowledge inferences in Experiment 1 and a greater difference between ignorance and knowledge in Experiment 2, two predictions which are not borne out.<sup>8</sup> By contrast, Beltrama et al.’s (2018) explanation in terms of a ban on discourse-initial focus on polarity is perfectly compatible with our results.

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<sup>7</sup>Take the two questions  $Q_1$  = “Who won?” and  $Q_2$  = “Did Croatia win?”. In inquisitive semantics,  $Q_1 \rightarrow Q_2$ , which means that anyone who can answer  $Q_1$  can also answer  $Q_2$ . Conversely, the chance that the addressee cannot give a complete answer is higher with  $Q_1$  than with  $Q_2$ . In some occasions, she will be able to resolve  $Q_2$  but not  $Q_1$  (e.g., if she only knows that the winner was France or Belgium), hence G&R’s idea that  $Q_2$  is a less risky conversation move than  $Q_1$ . Nevertheless, knowing that the winner was France or Belgium, while not a complete answer to  $Q_1$ , is still relevant as a partial answer. Because the complete answers to  $Q_1$  are at least partial answers to  $Q_2$ , under the assumption that cooperative speakers do give any relevant information (even if it only partially resolves the question),  $Q_1$  always result in at least as much information gain as  $Q_2$ .

<sup>8</sup>Beltrama et al. (2018) do not discuss a closely related proposal by van Rooy and Šafářová (2003), who assume that NAQs require equal utility for the two alternatives, while plain polar question either impose no requirement or favor higher utility for the positive alternative. This would also predict that NAQ are more degraded in ignorance situations than polar questions, and better than polar questions in knowledge situations.

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