# Bias in high negation questions as a quantity implicature in commitment space semantics*

Daniel Goodhue

Leibniz-Zentrum Allgemeine Sprachwissenschaft, Berlin, Germany
goodhue@leibniz-zas.de

**Abstract**

I analyze high negation as scoping over a commitment operator in a Commitment Space Semantics, building on [9]. I propose that polar questions chart two possible future courses through the commitment space, each rooted in a different possible commitment by the addressee. This semantics enables speaker bias in high negation questions to be derived as a special Quantity implicature, in competition with their positive polar question alternatives.

## 1 Bias and high negation

English high negation questions (HNQs) like in (1) necessarily convey that the speaker is biased for the positive answer, i.e. the propositional prejacent of the question embedded under negation. Prior work identifies HNQs crosslinguistically (Spanish, Bulgarian, Korean, German, Hungarian, Greek, and Turkish Sign Language; [14, 6, 5, 3]).[1]

(1) S: Didn't Mo eat? $\rightsquigarrow$ S is biased for the proposition *that Mo ate*

Unlike HNQs, positive polar questions (PPQs) and low negation questions (LNQs) do not necessarily convey speaker bias. Based on examples in [4], the contexts in (2) and (3) establish that the speaker S has no expectations about the answer to the question. Despite this lack of bias, the PPQ is acceptable in (2) while the LNQ is acceptable in (3). Meanwhile, HNQs are unacceptable in (2) and (3) because they necessarily convey a bias that S lacks in the contexts.

(2) S wants to find her roommate Mo, but has no expectations about whether Mo is home or not. She walks in the front door, sees their mutual roommate A and asks:
   a. Is Mo home? (PPQ)
   b. #Isn't Mo home? (HNQ)

(3) S wants to find her roommate Mo, but has no expectations about whether Mo is home or not. She looks everywhere and can't find Mo. But S does find their mutual roommate A in the last room that she checks. S says to A:
   a. Is Mo not home? (LNQ)
   b. #Isn't Mo home? (HNQ)

This asymmetry between HNQs on the one hand and PPQs and LNQs on the other raises the question, why does high negation give rise to this speaker bias in polar questions? In particular, what role is the preposing of negation playing?

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[1] '$\rightsquigarrow$' indicates an inference arising from an utterance, without implying any particular analysis of it.

To address the latter question, [4, §4.2] provides several empirical tests showing that HNQs lack a negation in their prejacent, of which I will demonstrate two. *Again* presupposes that the proposition denoted by its complement has happened before. Since presuppositions project out of questions, we can check to see if the presupposition contains negation.

(4) Did Mo not eat again?
*presupposes*: Mo did not eat before

(5) Didn't Mo eat again?
*presupposes*: Mo ate before

In the LNQ in (4), the negation can be part of the presupposition. But in the HNQ in (5), it cannot, which shows that the high negation is too high for *again* to scope above.

*Until*- and *for*-adverbials only combine with clauses that have durative rather than punctual aspect. Adding negation to a clause with punctual aspect creates durative aspect. Thus *until*- and *for*-adverbials are acceptable in (6). However, they are not in HNQs.

(6) a. Did Mo not discover Bo until 9?
b. Did the ball not hit the ground for two minutes?

(7) a. #Didn't Mo discover Bo until 9?
b. #Didn't the ball hit the ground for two minutes?

This data suggest that *until*- and *for*-adverbials cannot scope above high negation.

In light of the facts discussed so far, there are two disiderata driving my treatment of polar questions:

1. A location for high negation in HNQs that explains the absence of negation in their prejacent (see section 2).

2. A semantics for HNQs that makes them weaker than their PPQ alternatives (see section 3), which will be crucial for the derivation of speaker bias in section 4.

## 2 Commitment space semantics

The Commitment Space Semantics developed here builds on [9]. A *commitment state* (CSt) is a context set, a set of worlds compatible with all the mutually shared commitments in the common ground à la [16]. *Commitment spaces* (CS) are sets of CSts that model future developments of the current CSt. Since new commitments shrink CSts, smaller CSts are possible continuations, as in (8a). CSs are rooted in a set of their largest CSts, as in (8b).

(8) a. If CSts $c, c'$ are in CS $C$, and $c' \subset c$, then $c'$ is a possible continuation of $c$ in $C$.
b. $\sqrt{C}$, the root of $C$, is defined as $\{c \in C \mid \neg\exists c' \in C\ [c \subset c']\}$ [9, p. 68]

In Commitment Space Semantics, logical forms include distinct syntactic layers representing aspects of speech act structure, as in the LF for a PPQ in (9) [9, p. 64ff.]. Tense Phrases (TP) denote propositions, functions from possible worlds to truth values that characterize sets of worlds. Commitment Phrases (ComP) house the commitment operator '$\vdash$', which when combined with the TP also denote propositions. Speech Act Phrases (ActP) house speech act operators like question '**?**', that when combined with the ComP produce functions from Commitment Spaces to Commitment Spaces, similar to other dynamic semantics.

(9) $[_{\text{ActP}}$ Did$_k$ **?** $[_{\text{ComP}}$ $\vdash$ $[_{\text{TP}}$ Mo $t_k$ eat ] ] ] ('$[_{\text{TP}}$ Mo ate ]' abbreviated below as $\phi$)

Given these structural assumptions, high negation can be analyzed as scoping above '$\vdash$', as in (10). This makes good on disideratum 1, explaining why the tests in section 1 demonstrate a lack of negation in the prejacent of HNQs, on the assumption operators like *again* and *until*- and *for*-adverbials cannot scope into the speech act structure.

(10) $[_{\text{ActP}}$ Did$_k$ **?** $[_{\text{ComP}}$ n't $\vdash$ $[_{\text{TP}}$ Mo $t_k$ eat $(\phi)$ ] ] ]

I model commitment as a kind of attitude predicate in (11). $\mathcal{R}_j$-accessible worlds are those that are compatible with the judge $j$'s commitments in $w$. If $j$ commits to a proposition $p$, it means $j$ claims publicly that $p$ is true, and that $j$ will provide arguments supporting $p$ if $p$ were to be challenged [12, 1, 11, 8].

(11) $[\![\vdash]\!]^{i,\,d,\,g} = \lambda p.\lambda w.\ \forall w'[w\mathcal{R}_j w' \rightarrow p(w') = 1]$ (abbreviated as: $\lambda p.\lambda w.\vdash_{j,w} p$)

The interpretation function has three parameters, a set of the interlocutors $i$, a set of salient discourse referents $d$, and an assignment function $g$. $j$ is a variable in the assignment function $g$ whose value is fixed by whichever speech act operator is in ActP. An assertion operator in ActP shifts $j$ to the speaker $S$ in the $g$ of its complement, while the question operator **?** shifts $j$ to the addressee $A$ in the $g$ of its complement, in addition to having other effects that are elided for the moment in (12).

(12) $[\![\textbf{?}\ \alpha]\!]^{i,\,d,\,g} = \lambda C.\ \ldots\ [\![\alpha]\!]^{i,\,d,\,g[j\,\rightarrow\,A]}\ \ldots$

## 3 Interpretations for PPQs and HNQs

For Krifka, polar questions are usually assumed to restrict the CS to just those developments in which $A$ makes the commmitment in ComP. E.g. (9) would produce $\sqrt{C}\ \cup \{c \in C \mid c \subseteq \lambda w.\vdash_{A,w} \phi\}$. This model leaves out CSts in which $A$ makes a commitment other than the one in the ComP of the question, e.g. $\vdash_{A,w} \neg\phi$. I revise [9]'s denotation for the question operator '**?**' to output a multi-rooted CS that charts two opposing paths through the commitment space.

The idea for **?**'s semantics is intuitive enough: **?** takes an input ComP, and it projects two opposing future continuations of the conversation:

- Continuation 1: A makes the commitment $[\![[_{\text{ComP}}\ \alpha]]\!]$.
- Continuation 2: A makes a commitment to an alternative, $[\![[_{\text{ComP}}\ \alpha']]\!]$, that would be incompatible with $[\![[_{\text{ComP}}\ \alpha]]\!]$, i.e. $[\![[_{\text{ComP}}\ \alpha]]\!] \cap [\![[_{\text{ComP}}\ \alpha']]\!] = \varnothing$

But if the idea for **?** is intuitive, the implementation is not. The simplest way to find an alternative that would be incompatible with $[\![[_{\text{ComP}}\ \alpha]]\!]$ would be to negate it, i.e. $[\![[_{\text{ComP}}\ \alpha']]\!] = \neg[\![[_{\text{ComP}}\ \alpha]]\!]$. This would make **?** similar to a standard $Q$ morpheme. However, given the LFs for PPQs in (9) and HNQs in (10), this is a nonstarter because the denotations of PPQs and HNQs would be identical, predicting no meaning differences between them and so failing to satisfy desideratum 2.

What is needed is for **?** to be able to 'see' the TP proposition, in addition to its complement ComP. Then, given the meaning $[\![[_{\text{ComP}}\ \alpha]]\!]$, **?** can produce the opposing meaning $[\![[_{\text{ComP}}\ \alpha']]\!]$ by either negating the TP or not, and then combining the result with a commitment operator $\vdash$:

(13) a. If $[\![[_{\text{ComP}}\ \alpha]]\!] = \lambda w.\vdash_{j,w} \phi$, then $[\![[_{\text{ComP}}\ \alpha']]\!] = \lambda w.\vdash_{j,w} \neg\phi$,
since $\lambda w.\vdash_{j,w} \phi\ \cap\ \lambda w.\vdash_{j,w} \neg\phi = \varnothing$

b. If $[\![[_{\text{ComP}}\ \alpha]]\!] = \lambda w.\neg\vdash_{j,w}\phi$, then $[\![[_{\text{ComP}}\ \alpha']]\!] = \lambda w.\vdash_{j,w}\phi$,
since $\lambda w.\neg\vdash_{j,w}\phi \cap \lambda w.\vdash_{j,w}\phi = \varnothing$

To give a semantics for '**?**' that achieves this, I assume that TPs produce propositional discourse referents $\text{DR}_\phi$ (cf. [7] & [13]) that are recorded in the parameter $d$, and that are accessed by the question operator **?**.[2] **?** has the syncategorematic semantics in (14). It is a function from an input CS $C$ to an output CS restricted to those elements $c$ in $C$ that are subsets of either $[\![[_{\text{ComP}}\ \alpha]]\!]$ or $[\![[_{\text{ComP}}\ \alpha']]\!]$. The polarity operator variable '$y$', based on an idea proposed by [15, p. 17]), is **?**'s means of either negating the TP $\text{DR}_\phi$ or not, depending on what $[\![[_{\text{ComP}}\ \alpha]]\!]$ is.

(14) $[\![\ \textbf{?}\ [_{\text{ComP}}\ \alpha]]\!]^{i,d,g} = \lambda C.\,\{c \in C \mid c \subseteq [\![[_{\text{ComP}}\ \alpha]]\!]^{i,d,g[j\to A]} \vee c \subseteq [\![\vdash]\!]^{i,d,g[j\to A]}(y(\text{DR}_\phi))\}$, where $y$ is a variable ranging over polarity operators—i.e. $y \in \{\lambda p.p, \neg\}$—set to whichever operator produces an alternative commitment incompatible with $[\![[_{\text{ComP}}\ \alpha]]\!]^{i,d,g[j\to A]}$, i.e.: $[\![[_{\text{ComP}}\ \alpha]]\!]^{i,d,g[j\to A]} \cap [\![\vdash]\!]^{i,d,g[j\to A]}(y(\text{DR}_\phi)) = \varnothing$.

Alternatively, we can think of **?** as a conditional function as in (15):

(15) $[\![\ \textbf{?}\ [_{\text{ComP}}\ \alpha]]\!]^{i,d,g} = \lambda C.\,\{c \in C \mid c \subseteq [\![[_{\text{ComP}}\ \alpha]]\!]^{i,d,g[j\to A]} \vee c \subseteq \ldots$

a. $[\![\vdash]\!]^{i,d,g[j\to A]}(\text{DR}_\phi)\}$, if $[\![[_{\text{ComP}}\ \alpha]]\!]^{i,d,g[j\to A]} \cap [\![\vdash]\!]^{i,d,g[j\to A]}(\text{DR}_\phi) = \varnothing$

b. $[\![\vdash]\!]^{i,d,g[j\to A]}(\neg\text{DR}_\phi)\}$, if $[\![[_{\text{ComP}}\ \alpha]]\!]^{i,d,g[j\to A]} \cap [\![\vdash]\!]^{i,d,g[j\to A]}(\neg\text{DR}_\phi) = \varnothing$

(14) or (15b) produces the CS in (16) for the PPQ in (9):[3]

(16) $[\![\text{Did Mo eat?}]\!]^{i,d,g} = \{c \in C \mid c \subseteq \lambda w.\vdash_{A,w}\phi \ \vee\ c \subseteq \lambda w.\vdash_{A,w}\neg\phi\}$

In producing (16), $y$ is set to $\neg$ (put otherwise, (15b) is chosen) because $\lambda w.\vdash_{A,w}\phi \cap \lambda w.\vdash_{A,w}\neg\phi = \varnothing$, whereas if $y$ had been set to $\lambda p.p$, the two propositions would have been identical.

To compare this with the HNQ in (10), consider the semantics for the HNQ's ComP in (17), and the resulting CS in (18):

(17) $[\![\ \text{n't}\ ]\!]^{i,d,g}\ ([\![\vdash\ [_{\text{TP}}\ \phi\ ]\ ]\!]^{i,d,g}) = \lambda p.\lambda w.\neg p(w)\ (\lambda w.\vdash_{j,w}\phi) = \lambda w.\neg\vdash_{j,w}\phi$

(18) $[\![\text{Didn't Mo eat?}]\!]^{i,d,g} = \{c \in C \mid c \subseteq \lambda w.\neg\vdash_{A,w}\phi \ \vee\ c \subseteq \lambda w.\vdash_{A,w}\phi\}$

To produce (18), $y$ is set to $\lambda p.p$ (put otherwise, (15a) is chosen) because $\lambda w.\neg\vdash_{A,w}\phi \cap \lambda w.\vdash_{A,w}\phi = \varnothing$, whereas if $y$ had been set to $\neg$, there would have been entailment relation between the two propositions.

Both (16) and (18) have two mutually incompatible root CSts that lead to incompatible continuations: Each has a root in which $\vdash_{A,w}\phi$; and while (16) has a $\vdash_{A,w}\neg\phi$ root, (18) has a $\neg\vdash_{A,w}\phi$ root. (14)/(15) achieves this by producing CSs that include the ComP commitment and its obvious alternative given the TP prejacent proposition.

[2]An alternative to assuming $\text{DR}_\phi$ in $d$ would be to preserve $\text{DR}_\phi$ in the compositional semantics via an ordered pair representation of the TP such that $[\![[_{\text{TP}}\ \phi]]\!] = \langle\phi, \text{DR}_\phi\rangle$ (cf. [10, p. 6]). Composition rules would then be revised to operate on the first coordinate of the ordered pair, while the discourse referent is passed up the structure in the second coordinate.

[3]In (16) and the following, I overload the symbol '$\phi$': In the object language, '$\phi$' is an abbreviation for the TP constituent '[$_{\text{TP}}$ Mo ate ]'. In the metalanguage, '$\phi$' is an abbreviation for the proposition denoted by that TP '$\lambda w.$ *Mo ate in w*'. I.e. $[\![\phi]\!] = \phi$. Moreover, $\text{DR}_\phi$ has the same meaning: $[\![\text{DR}_\phi]\!] = [\![\phi]\!]$.

## 4 Speaker bias as quantity implicature

Taking the familiar case of sentences with **all** vs. **some**, quantity implicature can be thought of as depending on the (defeasible) conditional in (19). If $S$ says **some**, then the consequent doesn't hold, and by *modus tollens* S doesn't believe **all**, which can be strengthened into ¬**all**.

(19) If $S$ believes **all**, then **all** is more useful to utter than **some** (because it is more informative).

Compare the preceding to the following derivation of speaker bias. I posit the conditional in (20):

(20) If $S$ is ignorant of whether $p$ or $\neg p$, then the PPQ with prejacent $p$ (PPQ-$p$) is more useful than HNQ-$p$.

(20) depends on the assumption that if $S$ is ignorant about some relevant $p$, then their goal is to gain information about it. (20) also depends on the claim that any PPQ-$p$ is more informative than HNQ-$p$. The semantics in (16) and (18) deliver this: The CS in (16) is a proper subset of that in (18), and in particular, one of the root CSts of (16) is a proper subset of one of the root CSts of (18). This in turn depends on the simple fact that $\lambda w. \vdash_{A,w} \neg\phi$ entails $\lambda w. \neg \vdash_{A,w} \phi$. Relative informativity of questions is defined as follows:

(21) $Q_1$ is more informative than $Q_2$ iff the following two conditions are satisfied:
a. $\exists c \in \sqrt{Q_1}\ [\exists c' \in \sqrt{Q_2}\ [c \subset c']]$ b. $\forall c \in \sqrt{Q_1}\ [\neg\exists c' \in \sqrt{Q_2}\ [c' \subset c]]$

If $S$ chooses to use HNQ-$p$ instead of PPQ-$p$, it implies that PPQ-$p$ is not more useful. Given (20) and *modus tollens*, this implies that $S$ is not ignorant of whether $p$ or $\neg p$. In other words, $S$ is either biased for $p$ or for $\neg p$. This bias implicature is not cancellable because whenever HNQ-$p$ is relevant, the more informative PPQ-$p$ alternative is also relevant, since both are about the same prejacent proposition $p$.

With this non-directional bias in hand, the last step is to explain why HNQ-$p$ always conveys bias for $p$ (as opposed to $\neg p$). This can be read off of the structure of the CS in (18). Suppose $S$ were biased for $\neg\phi$. If $A$ were to pursue the commitment in the first disjunct in (18), then $S$ would know that $S$ and $A$ have a difference of opinion with respect to $\phi$. But if $A$ were to pursue the commitment in the second disjunct in (18), $S$ would not yet know whether $A$ agrees with $S$ that $\neg\phi$. This is because $A$'s lack of commitment to $\phi$ does not imply a commitment to $\neg\phi$; it is also compatible with a lack of commitment either way, for both $\phi$ and $\neg\phi$. Compare this with the case in which $S$ is biased for $\phi$. In that case, a choice by $A$ to pursue the commitment in either disjunct in (18) would immediately reveal to $S$ whether or not they are on the same page with respect to $\phi$: the first disjunct means they agree about $\phi$, the second that they do not. Thus if the goal of conversation is to grow the common ground via mutual commitment, then it only makes sense to use an HNQ when biased for the TP proposition that the HNQ is built from.

## 5 Comparisons to other approaches

One reviewer for the $AC$ points out an asymmetry between the above account and [9]: [9] provides a monopolar analysis of polar questions so that they only project continuations in which A makes the commitment in the ComP, as mentioned above. One benefit of [9]'s approach is it produces distinct semantics for PPQs, LNQs, HNQs, and negative alternative questions

(NAQs) like *Did Mo eat or didn't she?*. As for the account I have developed, although I didn't provide a semantics for LNQs or NAQs, I agree with the reviewer that my semantics, without any further changes, predicts PPQs, LNQs, and NAQs to all have the same semantics (while the semantics for HNQs will of course be unique). Giving a complete account of LNQs and NAQs is beyond the scope of this paper, but I would aim to explain the unique properties of NAQs via the fact that both alternatives are overtly uttered, which makes each alternative equally salient (cf. discussion of salience in [7], and highlighting in [13]). As for the well known difference in evidential bias between PPQs and LNQs, I would similarly like to exploit the difference in the prejacents uttered, the overt negation in LNQs in particular, and I would aim to explain the negative evidential bias conveyed by LNQs via the markedness of negation (cf. discussion in [2, 18, 17, 13]).

Another reviewer wonders how HNQs relate to assertions on my account. While I don't make this claim here, in [4] I argue that the bias in HNQs may be as strong as full belief (at least in some cases). The reviewer asks why an S who believes $p$ would use HNQ-$p$ instead of asserting $p$. As I discuss in [4], HNQs are useful for determining agreement. S may have believed $p$ up until a few moments before uttering the HNQ as the result of being confronted with evidence against $p$. Another possibility discussed in [4] is that HNQs are often reserved for use in contexts in which A has at least as much epistemic or social authority over whether or not $p$ is true as S does. Such contexts make S more likely to use an HNQ, to simultaneously convey their bias for $p$ while giving A control over whether $p$ is determined to be true or not. Exploitation of this authority asymmetry may also be used to allow A to save face.

As for the strength of bias, my account does not require bias to be as strong as full belief. To achieve a weaker bias, (20) would need to be reconsidered. If the negation of ignorance of whether $p$ or $\neg p$ is belief in either $p$ or $\neg p$,[4] then to weaken the bias, the antecedent of (20) needs to be strengthened to something like 'complete ignorance', i.e. not only does the antecedent say that S is ignorant, but that S isn't even leaning one way or the other with respect to $p/\neg p$. Then, negating that will derive a weaker non-directional bias, namely that S *is* leaning one way or the other with respect to $p/\neg p$.

Finally, two reviewers ask how this relates to other accounts generally. I discuss a different version of my account relative to others in [4]. The present account represents progress over my account in [4] in that it provides a unified syntax/semantics for the left-periphery, with a clear dynamic view of context update, and a semantics for PPQs and HNQs that are directly related via entailment, which is a crucial precondition for the bias derivation in section 4. One advantage of this account is that the mechanics of the bias derivation is clear. Another is that the account does not unify HNQ bias with bias in other questions, such as polarity/verum focus questions, which appear to be empirically distinct (see discussion in [4]).

## 6 Conclusion

On the basis of a uniform commitment space semantics and syntax, the present account explains why preposed negation in polar questions conveys speaker bias crosslinguistically: because preposing *n't* scopes it over $\vdash$, which produces a less informative question than its competitor without *n't*.

[4] Let '*Bel*' stand for 'belief', i.e. doxastic necessity. Ignorance of whether $p$ or $\neg p$ can be written as $\neg Bel\, p \;\wedge\; \neg Bel\, \neg p$. Then the negation of ignorance entails belief in either $p$ or $\neg p$:
$\neg[\neg Bel\, p \;\wedge\; \neg Bel\, \neg p] = Bel\, p \;\vee\; Bel\, \neg p$

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