Chapter 6

Contextual bias and the landscape of Mandarin polar questions

Yurie Hara
Hokkaido University

Mengxi Yuan
Jinan University

Mandarin Chinese has at least three kinds of polar questions, positive *ma* questions, negative *ma* questions and A-not-A questions, which have similar semantics but are not totally interchangeable. In particular, they carry different bias connotations. We show that their bias meanings and distribution are best characterized by the notion of contextual bias, which is formalized in terms of the subjective probability distribution within the framework of Farkas & Bruce's (2010) Table model. Our analysis offers a simple lexical semantics for *ma* questions by employing pragmatic competition, and supports the idea that prosodic contours like the Final Fall in A-not-A questions are intonational morphemes that carry semantic contents.

1 Introduction

According to Hamblin's (1958, 1973) seminal theory of questions, a question denotes a set of propositions that count as possible answers to it, which predicts that there is no semantic difference between English positive polar questions, negative polar questions and alternative questions of the form '*p* or not *p*?'. However, a number of subsequent studies present evidence that these questions have different properties and are not always interchangeable (Bolinger 1978, Ladd 1981, Büring & Gunlogson 2000, Van Rooy & Šafářová 2003, Romero & Han 2004, Biezma 2009, Roelofsen & van Gool 2010, Biezma & Rawlins 2012, Sudo 2013, Krifka 2015, Domaneschi et al. 2017, Farkas & Roelofsen 2017, a.o.).

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Mandarin Chinese also has three types of polar questions that are not interchangeable: positive *ma* questions (+MAQ), negative *ma* questions (−MAQ) and A-not-A questions (ANAQ). *Ma*-questions, henceforth MAQs, are formed by attaching a question particle *ma* at the end of the sentence as in (1–2). As we will see below, positive and negative *ma* questions are in complementary distribution.

(1) Xia yu le ma?
fall rain PERF Q
'Did it rain?' (+MAQ)

(2) Mei xia yu ma?
not fall rain Q
'Did it not rain?' (−MAQ)

A-not-A questions, henceforth ANAQs, conjoin the verb and its negative counterpart and end with an obligatory final boundary low tone L% (henceforth the final Low tone is indicated by as '↓') and an optional question particle *ne*:

(3) Xia mei xia yu (ne)?↓/L%
fall not fall rain Q
'Did it rain or not rain?' (ANAQ)

While intuitively (1–3) are asking the same question of whether it rained, they are used in different contexts. This naturally raises the following question: What determines the distribution of the three kinds of questions? Yuan & Hara (2019) discuss the syntactic and prosodic differences among the three constructions as well as the differences in compositional semantics. The current paper focuses on the bias profile/type of bias that arise from these constructions.

2 Data

This section presents the main empirical observation regarding Mandarin polar questions. In particular, we show which constructions are available in what kind of contexts.

2.1 Positive *ma* question

Let us first take a look at positive *ma* questions (+MAQ). A +MAQ can be used in out-of-blue contexts where no conversation participants have expressed any bias:

(4) A researcher uses a questionnaire to investigate the relationship between the weather and people's mental states. The first question in the questionnaire is:
Ni de chengshi zuotian xia yu le ma?
you GEN city yesterday fall rain PERF ma
'Did it rain yesterday in your city?' (+MAQ)

It can also be used in positively biased contexts. In (5), Speaker A's assertion of p renders the context biased towards p.

(5) A: Zuowan (henkeneng) xia yu le.
last-night probably fall rain PERF
'(Probably,) It rained last night.'
B: Xia yu le ma?
fall rain PERF ma
'Did it rain?' (+MAQ)

+MAQ are also felicitous in contexts that are non-verbally biased towards p:

(6) B enters A's windowless room wearing a dripping wet raincoat.
A: Xia yu le ma?
fall rain PERF ma
'Did it rain?' (+MAQ)

In contrast, when the context is biased toward $\neg p$, a +MAQ cannot be used:

(7) A and B open the window and find the ground dry. A speaks to B, who stayed up all night.
A: #Zuowan xia yu le ma?
last-night fall rain PERF ma
'Did it rain last night?' (+MAQ)

As summarized in Table 1, +MAQs are felicitous when the context is neutral or positively biased.

2.2 Negative *ma* questions

Negative *ma* questions (−MAQs) are in complementary distribution with +MAQs. Thus, they cannot be used in an out-of-the-blue context like (8).

Table 1: Distribution of positive MAQs

	Neutral	biased towards p	biased towards $\neg p$
positive MAQs	✓	✓	#

(8) A researcher uses a questionnaire to investigate the relationship between the weather and people's mental states. The first question in the questionnaire is:

Ni de chengshi zuotian mei xia yu ma?
you GEN city yesterday NEG fall rain ma
'Did it not rain yesterday in your city?' (−MAQ)

Negative MAQs are also disallowed in positively biased contexts as in (9–10).

(9) A: Zuowan (henkeneng) xia yu le.
last-night probably fall rain PERF
'It (probably) rained last night.'
B: #Mei xia yu ma?
NEG fall rain ma
'Did it not rain?' (−MAQ)

(10) B enters A's windowless room wearing a dripping wet raincoat.
A: #Mei xia yu ma?
NEG fall rain ma
'Did it not rain?' (−MAQ)

This raises the questions of when -MAQs can be used. The answer is that they can be used in contexts that exclude +MAQs when the context is biased towards $\neg p$. The bias can arise verbally as in (11) or non-verbally as in (12).

(11) A: Zuowan mei xia yu.
last-night NEG fall rain
'It did not rain last night.'
B: Mei xia yu ma?
NEG fall rain ma
'Did it not rain?' (−MAQ)

(12) B leaves A's windowless room carrying a raincoat. When B returns, A notices that B's raincoat is dry.

A: Mei xia yu ma?
NEG fall rain ma
'Did it not rain?' (−MAQ)

Table 2 summarizes the distribution of MAQs. Positive and negative MAQs are in complementary distribution. Negative MAQs are uttered when the context is biased towards $\neg p$ while positive MAQs are uttered elsewhere, i.e., when the context is neutral or biased towards p.[1]

Table 2: Distribution of MAQs

	Neutral	biased towards p	biased towards $\neg p$
positive (+) MAQs	✓	✓	#
negative (-) MAQs	#	#	✓

2.3 A-not-A question

A-not-A questions are used only in neutral contexts as in (13).

[1]In Mandarin, there is another type of polar questions that contains a negation morpheme *bu-shi*. *Bu-shi* questions, like English inner high negation questions, are used when the speaker has a prior bias toward the positive answer but the utterance context is biased toward the negative one as in (i). This example was suggested by the reviewer, and the reviewer pointed out that this example is a high negative polar question. We clarify that this paper only discusses the semantics of unmarked negative *ma* questions which are comparable to low negative polar questions in English, and we don't discuss the semantics of *bu-shi* questions (which are comparable to high negative polar questions in English).

(i) B told A that he was married. On the next day, A found B at a bachelor party.
A: ni bu-shi jiehun-le ma?
you not-SHI married-ASP Q
'Aren't you married?'

bu-shi questions are distinct from (negative) MAQs. *Bu-shi* questions are comparable to high negative polar questions in English and unmarked negative MAQs are comparable to low negative polar questions in English. See Fu (2021) for an analysis that uses Romero & Han's (2004) VERUM operator.

(13) A researcher uses a questionnaire to investigate the relationship between the weather and people's mental states. The first question in the questionnaire is:

A: Ni de chengshi zuotian xia mei xia yu?↓
you GEN city yesterday fall not fall rain
'Did it rain or not rain yesterday in your city?' (ANAQ)

Once the context is biased towards either answer, questioning with an ANAQ becomes infelicitous. In (14–15), the context is positively biased and the ANAQ is ruled out:

(14) A: Zuowan xia yu le.
last-night fall rain PERF
'It rained last night.'
B: #Xia mei xia yu?↓
fall NEG fall rain
'Did it rain or not rain?' (ANAQ)

(15) B enters A's windowless room wearing a dripping wet raincoat.
A: #Xia mei xia yu?↓
fall NEG fall rain
'Did it rain or not rain?' (ANAQ)

Likewise, in (16–17), the context is negatively biased and the ANAQ is infelicitous.

(16) A: Zuowan mei xia yu.
last-night NEG fall rain
'It did not rain last night.'
B: #Xia mei xia yu?↓
fall NEG fall rain
'Did it rain or not rain?' (ANAQ)

(17) B leaves A's windowless room carrying a raincoat. When B returns, A notices that B's raincoat is dry.
A: #Xia mei xia yu?↓
fall NEG fall rain
'Did it rain or not rain?' (ANAQ)

Table 3: Distribution of MAQs and ANAQs

	neutral	biased towards p	biased towards $\neg p$
positive MAQs	✓	✓	#
negative MAQs	#	#	✓
ANAQs	✓	#	#

Table 3 summarizes the distribution of +/− MAQs and ANAQs.

The next question we will address is what kind of bias is involved. Put another way, what exactly does it mean to say 'the context is biased/neutral'?

3 Question bias in traditional grammar

Traditional grammarians attempted to analyze the meanings of MAQs and ANAQs with regard to the speaker's bias. On the one hand, most traditional linguists conclude that the speaker of a ANAQ is neutral between a positive and a negative answer. On the other hand, the nature of the bias expressed by MAQs was controversial. According to Wang (1943: 168), for instance, MAQs are confirmation-seeking questions that encode the speaker's bias towards the prejacent proposition p, whereas Chao (1968: 356) and Shao (1996: 72) claim that MAQs signify the speaker's bias towards the negation of the prejacent proposition $\neg p$.

We regard these traditional approaches as problematic in several respects. First, the semantics of MAQs and ANAQs and their biases are not compositionally derived but stipulated (see Yuan & Hara 2019 for compoisitional semantics of these questions). Second, empirical data shows that the bias is not lexically encoded in MAQs. To illustrate, the speaker of the +MAQ in (6) seems to be biased towards the positive answer while the speaker in (4) seems to be neutral. As shown in (18), furthermore, the same +MAQ can be uttered in various contexts with different speaker biases. If a +MAQ were a lexically biased question, that is, if a +MAQ obligatorily denoted the speaker's bias towards the positive answer, then (18a) and (18c) would be unacceptable since the continuations contradict the semantic content of the +MAQ .

(18) Xia yu le ma? ...
fall rain PERF ma
'Did it rain? ...'

a. ... Wo bu juede.
I NEG think
'... I don't think so.'

b. ... Wo cai xia le.
I guess fall PERF
'... I guess it rained.'

c. ... Wo wanquan bu qingchu.
I totally NEG clear
'... I totally have no idea.' (+MAQ)

Furthermore, the speaker does not need to be neutral about the answers when she utters an ANAQ. The speaker in (4) is probably neutral regarding the answers, while she can hold a private bias toward either answer in some other contexts. For instance, A in (19) can felicitously utter an ANAQ even though she is privately biased towards the positive alternative *You have questions*:

(19) A believes that his audience usually have questions to raise after his speech:
A: Nimen you mei you wenti?↓
you have not have questions
'Do you have or not have questions?' (ANAQ)

Similarly in (20), A is only privately biased towards the proposition *He looks like you*, that is, the other discourse participant does not know that A is biased towards p.[2]

(20) A and B are in the museum. A finds a portrait that looks like B.
A: (Kan!) Ta xiang bu xiang ni?
look he resemble not resemble you
'(Look!) Does he look like you or not like you?'

Finally, the notion of the speaker bias seems too strong to characterize the bias that arises from −MAQs. That is, the speaker does not need to have a strong belief that $\neg p$ in uttering a −MAQ. In (21), for instance, speaker A only considers a (slight) possibility of $\neg p$ or just reports that someone else other than the speaker mentioned $\neg p$, yet the context licences the use of the −MAQ.

[2]We owe example (20) to an anonymous reviewer.

(21) A1: Zuowan keneng mei xia yu.
last-night maybe NEG fall rain
'Maybe it did not rain last night.'
A2: Wo bu juede zuowan xia yu le.
I NEG think last-night fall rain PERF
'I don't think that it rained last night.'
A3: John shuo zuowan mei xia yu.
John say last-night NEG fall rain
'John said that it did not rain last night.'
B: Mei xia yu ma?
NEG fall rain ma
'Did it not rain?' (−MAQ)

In summary, the speaker bias is not in the lexical specification of either MAQs or ANAQs. As we argue below, the notion of 'contextual bias' is more appropriate to characterize the semantics and pragmatics of MAQs and ANAQs.

4 Proposals

To derive the distribution of the polar questions sketched in Section 2, we make the following proposals.

(22) a. The bias meaning involved in Mandarin polar questions are best characterized by the notion of contextual bias ('evidential bias' in Sudo 2013)
b. As for MAQs, only the negative MAQ lexically encodes the bias meaning.
c. The contextual neutrality of ANAQ is derived by the exhaustivity operator denoted by the final low tone ↓/L%.

When the context is biased toward $\neg p$, a −MAQ is the most optimal. Accordingly, a +MAQ is used elsewhere, i.e., in neutral and positively biased contexts as we have seen in Table 2, repeated here as Table 4. In Section 7.1, we show how the elsewhere condition explains the complementary distribution of positive/negative MAQs.

As for ANAQs, we argue that the exhaustive interpretation that arises from the final low tone ↓/L% is the source of the neutrality requirement. In a nutshell, ↓ expresses that the Hamblin alternatives presented by the A-not-A construction,

Table 4: Distribution of MAQs

	Neutral	biased towards p	biased towards $\neg p$
positive +MAQs	✓	✓	#
negative -MAQs	#	#	✓

i.e., p and $\neg p$, are the only live options. Thus, if the context is biased towards one of them, the context does not match the semantics of ↓.

In the next sections, we formalize the notion of contexual bias/neutrality and show how the distribution pattern of Mandarin polar questions can be derived.

5 Formalizing contextual bias

In formalizing the contextual bias, we start with the following working definition: A context c is biased toward p when someone's bias towards p is public:

(23) Contextual bias (informal version)
A context c is biased toward p iff
   a. it is a common belief that some individual x entertains the possibility of p, and
   b. there is no individual who entertains the possibility of $\neg p$.

To characterize some individual's epistemic state, we use the notion of subjective probability distribution (Jeffrey 2004, Potts 2007, McCready & Ogata 2007, Davis et al. 2007). In implementing the "common belief" part, we employ Farkas & Bruce's (2010) Table model.

5.1 Subjective probability distribution

The current paper follows the formulation given by Davis et al. (2007) and models a proposition (i.e., a set of possible worlds) as a probability distribution:

(24) A probability distribution for a countably finite set W is a function P^W from subsets of W into real numbers in the interval [0,1] obeying the conditions:
   a. $P^W(W) = 1$
   b. $P^W(\{w\}) \geqslant 0$ for all $w \in W$

c. If p and q are disjoint subsets of W, then $P^W(p \cup q) = P^W(p)+P^W(q)$.[3] (Davis et al. 2007: 77)

The epistemic state of an individual a is denoted by a proposition Dox_a, which is a finite set of possible worlds that are doxastically accessible to a. Now, the conditionalization of a uniform distribution is given in (25).

(25) Let $P(-|p)$ be the function that maps any proposition q to

$$P(q|p) = \frac{P(q \cap p)}{P(p)}$$

where P is a probability distribution. That is, $P(-|p)$ maps propositions to their conditional probabilities (for P) given p. $P(q|p)$ is undefined if $P(p) = 0$. (Davis et al. 2007: 77)

Based on this uniform distribution, a function Cred_a (Cred for 'credence') models the epistemic state of an individual a as in (26). The function Cred_a returns a's degree of belief in p:

(26) The subjective probability distribution for an individual a:

$$\text{Cred}_a = P(-|\text{Dox}_a)$$

in which P is a uniform distribution over W, i.e., $P(\{w\}) = \frac{1}{|W|}$ for all $w \in W$. (Modified from Davis et al. 2007: 77)

Thus, an individual a's degree of belief in a proposition p is calculated as follows:

(27)

$$\text{Cred}_a(p) = P(p|\text{Dox}_a) = \frac{P(p \cap \text{Dox}_a)}{P(\text{Dox}_a)}$$

Now let us calculate different belief states using (27). If a is committed to the proposition p, p is true in all the worlds in Dox_a, i.e., $\text{Dox}_a \subseteq p$. Since $p \cap \text{Dox}_a = \text{Dox}_a$, $\text{Cred}_a(p)$ returns 1:

(28)

$$\text{Cred}_a(p) = P(p|\text{Dox}_a) = \frac{P(p \cap \text{Dox}_a)}{P(\text{Dox}_a)} = \frac{P(\text{Dox}_a)}{P(\text{Dox}_a)} = 1$$

[3]We henceforth suppress the superscript W.

If a is committed to $\neg p$, p is true in no worlds in Dox_a. Thus, $\text{Cred}_a(p) = 0$:

(29)
$$\text{Cred}_a(p) = P(p|\text{Dox}_a) = \frac{P(p \cap \text{Dox}_a)}{P(\text{Dox}_a)} = \frac{\frac{0}{|W|}}{P(\text{Dox}_a)} = 0$$

Finally, agent a entertains the possibility of p when $\text{Cred}_a(p)$ is greater than 0:

(30) a entertains the possibility of p iff

$$\text{Cred}_a(p) > 0$$

where $a \in A$ and A is a set of epistemic agents.

Let us see how (30) works with linguistic examples. In (31) the speaker is committed to the proposition *p It rained*. That is, $\text{Cred}_{\text{spkr}}(p) = 1 > 0$, so the speaker entertains the possibility of p.

(31) Zuowan xia yu le.
last.night fall rain PERF
'It rained last night.'

Similarly, in (32), John believes p to be true, so $\text{Cred}_{\text{john}}(p) \geqslant 0.98 > 0$, thus John entertains the possibility of p.

(32) John shuo/juede zuowan xia yu le.
John said/belives last.night fall rain PERF
'John said/believes that it rained last night.'

In (33), the fact that B wears a wet raincoat is regarded as contextually compelling evidence (Büring & Gunlogson 2000) for the proposition *p It rained* that raises A's degree of belief in p to a value greater than 0.5 ($1 > \text{Cred}_{\text{A}}(p) > 0.5$, see McCready & Ogata 2007). Since $\text{Cred}_{\text{A}}(p) > 0$, agent A entertains the possibility of p.

(33) B enters A's windowless room wearing a wet raincoat.

This section formalized the "entertaining" part of the definition of contextual bias using the subjective probability distribution. Agent a entertains the possibility of p when $\text{Cred}_a(p)$ is greater than 0 as defined in (30).

We next turn to the rest of the definition, that is, how someone's epistemic state becomes a common belief of all conversation participants.

5.2 The Table model

We follow Farkas & Bruce's (2010) idea that when an issue that contains a proposition is pushed onto the conversation "Table", the proposition becomes a common belief. Thus, in our case, the context is biased towards p when an issue that contains the proposition that some individual entertains the possibility of p is pushed onto the Table, and no issue that contains $\neg p$ is pushed onto the Table.

The Table is one way to represent Questions Under Discussion (Roberts 1996) and defined as in (34). Let I be an issue, a set of propositions of type $\langle\langle s,t\rangle,t\rangle$. A Table T is a stack or an ordered pair of issues.

(34) The Table T:
Let I be an issue, a set of propositions.
a. $\langle\,\rangle$ is a Table.
b. If I is an issue and T is a Table, then $\langle I,T\rangle$ is a Table.
c. Nothing else is a Table.
d. If T is a Table, then $|T|$ is the length of the table and $T[n]$ is the nth element in the Table ($1 \leq n \leq |T|$; counting from 1 at the top).

If the Table is not empty, there is some issue to be solved. The topmost issue on the Table is the most-pressing issue that needs to be resolved. The ultimate goal of the conversation is to resolve all issues and empty the Table.

Stack operations such as push and pop are also introduced as operations for the Table in Farkas & Bruce (2010). Performing push(I,T) outputs a new stack by adding I to the top of the stack T:

(35) For any issue I and Table T:
push$(I,T) = \langle I,T\rangle$

The 'pop(I,T)' operation removes the topmost issue I from T:

(36) For any issue I and Table T:
pop$(I,T) = T$ if $T \neq \langle\,\rangle$; I otherwise.

Each Table is relativized to a context c, which has a basic semantic type c (see also Davis 2011).[4] Thus, T is now a function from contexts to Tables:

[4]In Farkas & Bruce's (2010) framework, a context state is understood as a tuple of elements such as the Common Ground, the Table, etc (see also Roelofsen & Farkas 2015). Speech act operators such as ASSERTION and QUESTION take sentences as arguments and yield functions from input context states to output context states.

(37) The Table in context:
Let c be a context, $T(c)$ is a Table at context c.

Similarly, the Stalnakerian (1978) Common Ground is obtained by a function CG that takes a context c and returns a set of propositions:

(38) The Common Ground:
Let c be a context, $\text{CG}(c)$ is a set of propositions that are shared by all the discourse participants at context c.

Speech acts are defined as functions from input contexts to output contexts. The ASSERT operator is of type $\langle\langle s,t\rangle,\langle \text{C},\text{C}\rangle\rangle$ and it takes a proposition p and yields a context change potential of type $\langle \text{C},\text{C}\rangle$:

(39) CCP of ASSERT (first version):
$\text{ASSERT}(p)(c) = c'$ such that
a. $\text{CG}(c') = \text{CG}(c) \cup (\text{Cred}_{\text{spkr}}(p) \geqslant 0.98)$
b. $T(c') = \text{push}(\{p\}, T(c))$

As can be seen in (39), an assertion of p updates the context in two ways. First, it adds to the $\text{CG}(c)$ a proposition that the speaker has a very high degree of belief in p ($Cred_{\text{spkr}}(p) \geqslant 0.98$). Second, it pushes $\{p\}$ onto the top of the Table.[5] This second update is one of the core features of Farkas & Bruce's (2010) Table model. In (40), A's assertion of *p It rained* is directly assented or dissented with by B. In other words, not only a question but but also an assertion can raise an issue. Thus, as soon as p is asserted, it is considered as an at-issue proposition on the Table that affects the future direction of the discourse (Farkas & Bruce 2010, Tonhauser 2012, Northrup 2014).

(40) A: Zuowan xia yu le.
last-night fall rain PERF
'It rained last night.'
B: Shide, xia yu le. / Bu-shide, mei-you xia yu.
yes fall rain PERF NEG-yes NEG-have fall rain
'Yes, it rained'/'No, it did not rain.'

[5]The second update on the Table will be dispensable as the first part automatically pushes p to the Table, so (39b) will be removed later.

Besides conversational moves such as an assertion or a question that are extensively discussed in Farkas & Bruce (2010), we propose that contextual compelling evidence is another conversational move that affects the context. For instance in (41), the fact that B wears a raincoat counts as evidence for the proposition *p It rained* which in turn increases A's degree of belief that p to some degree above 0.5.

(41) B enters A's windowless room wearing a wet raincoat.

Thus, contextual compelling evidence yields a context change potential. We define CCE based on McCready & Ogata's (2007) semantics of Japanese evidentials as in (42). The operator CCE presupposes that some evidence q has led a to raise her subjective probability of p above 0.5. For example, suppose that a holds a background knowledge $q \rightarrow p$ '*If someone wears a wet raincoat, it is raining*'. When a learns that q is true, by modus ponens, the probability of p ($P(p|\text{Dox}_a \cap q)$) becomes higher than before leaning q and 0.5. If the presupposition is satisfied, CCE combines with the proposition p and returns a CCP, which changes the context c by adding the proposition that '*A's degree of belief in p is larger than 0.5*' into the CG(c) and pushing the issue of p onto the Table $T(c)$.[6]

(42) CCP of CCE (contextual compelling evidence) (first version):
Let p, q be propositions and a be a discourse participant,
   a. $\text{CCE}_a(p)(c)$ is defined iff
   $\exists q.P(p|\text{Dox}_a \cap q) > P(p|Dox_a) \wedge P(p|\text{Dox}_a \cap q) > 0.5$
   b. If defined, $\text{CCE}_a(p)(c) = c'$ such that
      i. $\text{CG}(c') = \text{CG}(c) \cup (\text{Cred}_a(p) > 0.5)$
      ii. $T(c') = \text{push}(\{p\}, T(c))$

It follows that p is at-issue and up for debate, just like the issues pushed onto the Table by prototypical conversational moves such as assertion and question. Therefore, discourse participants can respond to a piece of contextual compelling evidence for the proposition *p It rained* by showing their agreement or disagreement with p, as illustrated in (43). Also, A's use of the anaphoric expression *zheyang* 'this' in (43) referring to p ('*I expected it rained*'/'*I don't believe it rained*') demonstrates that the existence of the contextual compelling evidence for p enables p to be the antecedent of the anaphor. This is possible because the contextual compelling evidence for p raises an issue $\{p\}$ that can be discussed in the subsequent discourse (see Snider 2017 for the discussion of at-issueness and anaphoric salience).

[6](42b-ii) will be removed later as a's high credence on p being part of the common ground is enough for p to be an issue on the Table.

(43) B enters A's windowless room wearing a wet raincoat.
A: Wo jiu zhidao (hui zheyang).
I PART know can this-like
'This is what I expected.'
A′: Bu keneng, wo bu xiangxin (hui zheyang).
NEG possible I NEG believe would this
'No way, I don't believe this (would happen).'

As can be seen from (40) and (43), as long as some individual publicly entertains the possibility of p, p becomes an issue that is on the Table for discussion. To implement this intuition, we propose that as long as some individual's consideration of the possibility of p is made public in a context c, the issue $\{p\}$ is pushed onto the Table at c:

(44) Pushing an issue onto the Table:
If $\text{CG}(c') = \text{CG}(c) \cup (\exists x.x \in A(c) \& \text{Cred}_x(p) > 0)$,
Then $T(c') = \text{push}(\{p\}, T(c))$.
where c' and c are the output context and input context respectively and $A(c)$ is the set of epistemic agents at c.

Now that (44) allows an issue $\{p\}$ to be on the Table as long as some individual considers p possible, the definitions of ASSERT and CCE are simplified as below:

(45) CCP of ASSERT (final version):
$\text{ASSERT}(p)(c) = c'$ such that $\text{CG}(c') = \text{CG}(c) \cup (\text{Cred}_{\text{spkr}}(p) \geqslant 0.98)$

(46) CCP of CCE (final version):
Let p, q be propositions and a be a discourse participant,
a. $\text{CCE}_a(p)(c)$ is defined iff
$\exists q.P(p|\text{Dox}_a \cap q) > P(p|Dox_a) \wedge P(p|\text{Dox}_a \cap q) > 0.5$
b. If defined, $\text{CCE}_a(p)(c) = c'$ such that $\text{CG}(c') = \text{CG}(c) \cup (\text{Cred}_a(p) > 0.5)$

Finally, we can formalize the contextual bias and neutrality. First, A context c is biased towards a proposition p if the issue $\{p\}$, but not $\{\neg p\}$, is on the Table in c:

(47) Contextual bias (final version)
A context c is biased towards a proposition p iff
$\{p\} \subseteq \bigcup_{x=1}^{n} T(c)[x]$ and $\{\neg p\} \nsubseteq \bigcup_{x=1}^{n} T(c)[x]$,
where $n = |T(c)|$.

We also define context neutrality as follows: The context is neutral with respect to p if no issue is on the Table or if both p and $\neg p$ are on the Table. More precisely, the context is neutral when the union of all the issues at each stack member of the Table amount to an empty set or contains the issue $\{p, \neg p\}$:

(48) The context c is neutral with respect to p iff $\bigcup_{x=1}^{n} T(c)[x] = \emptyset$ or $\{p, \neg p\} \subseteq \bigcup_{x=1}^{n} T(c)[x]$,
where $n = |T(c)|$.

To sum up, we formalize the notion of contextual bias using the subjective probability and the Table model. A context is biased towards p when the proposition that someone entertains the possibility of p becomes an issue of the Table.

6 Semantics of Mandarin polar questions

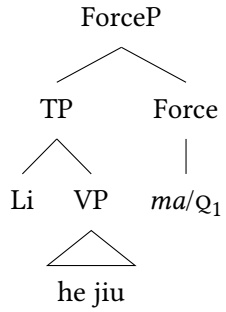
Before looking at how our notion of contextual bias derives the pattern summarized in Section 2, we briefly review the semantics of MAQ and ANAQ given by Yuan & Hara (2019). Furthermore, this paper adds felicity conditions on the semantics of −MAQ.

6.1 *Ma* Questions

Yuan & Hara (2019) claim that a MAQ like (49) has the syntactic structure given in (50).

(49) Li he jiu ma?
Li drink alcohol Q_1
'Does Li drink alcohol?'

(50)



The semantics of the particle *ma*/Q_1 is defined as in (51). The particle takes its sister proposition p as an argument, creates a Hamblin alternative $\{p, \neg p\}$ as an issue and pushes the issue onto the Table:

(51) CCP of Q_1:
$Q_1(p)(c) = c'$ such that $T(c') = \text{push}(\{p, \neg p\}, T(c))$

Now, we claim that −MAQs have a felicity condition (Searle 1965) in addition to the usual felicity condition of questions that +MAQs also have.[7] In a nutshell, a $\neg p$-*ma* is felicitous only when the context is biased towards $\neg p$, i.e., $\{\neg p\} \subseteq \bigcup_{x=1}^{n} T(c)[x]$ and $\{p\} \not\subseteq \bigcup_{x=1}^{n} T(c)[x]$:

(52) Felicity condition of −MAQ:
The use of a negative MAQ, i.e., a MAQ containing NegP as the maximal I-projection which denotes $\neg p$, is felicitous in a context c only if c is biased towards $\neg p$.

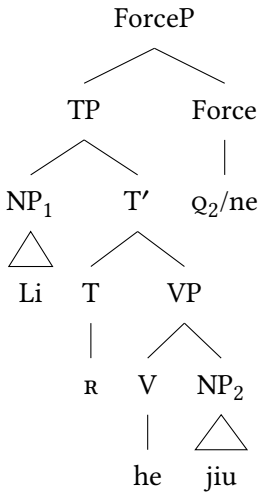
6.2 A-not-A questions

Turning to ANAQs, Yuan & Hara (2019) propose that an ANAQ like (53) has the structure in (54), adopting Huang's (1991) analysis. The feature R represents the reduplication of the predicate with the negative marker *bu*. The optional particle *ne* is the phonological realization of another question operator Q_2.

(53) Li he bu he jiu (ne)?↓
Li drink not drink alcohol Q_2
'Does Li drink or not drink alcohol?'

[7] See Trinh (2014) for an alternative analysis of the felicity conditions for positive and negative polar questions. Trinh (2014) makes two generalizations about the felicitous use of polar questions: 1. A polar question is felicitous only if its prejacent does not contradict the answer implied by contextual evidence; 2. In contexts where there is neither evidence for p nor evidence for $\neg p$, the question denoting $\{p, \neg p\}$ is felicitous only if it is an inverted positive question. Trinh (2014) explains the first generalization by adopting the Principle of Maximize Presupposition and explains the second one by adopting the Maxim of Manner: in a neutral context where there is neither evidence for p nor evidence for $\neg p$, the speaker will choose a positive polar question instead of a negative one because the former is simpler in syntactic form.

(54)



The reduplication feature R is responsible for creating a Hamblin set:

(55) Semantics of reduplication R
$[\![\text{R}]\!] = \lambda P.\lambda x.\{P(x), \neg P(x)\}$

The particle Q_2/*ne* pushes the Hamblin set created by R to the Table:

(56) CCP of the operator Q_2:
$Q_2(Q)(c) = c'$ such that $T(c') = \text{push}(Q, T(c))$

Finally, an ANAQ has to be uttered with a final L% boundary tone (↓). Following Biezma & Rawlins's (2012) analysis of English final falling tone of alternative questions, Yuan & Hara (2019) argue that the Mandarin final ↓/L% is a closure operator which indicates that there is no issue on the Table or the issue presented by the ANAQ is the only issue on the Table. The current paper proposes the following semantics for ↓:[8]

[8]An ANAQ followed by the particle *ne* can be uttered with final H%, as pointed out by an anonymous reviewer. We speculate that when an ANAQ containing *ne* is uttered with H% tone, the L% tone is overridden by H%. Thus, the source of neutrality is still L%. Our intuition is that when an ANAQ containing *ne* is uttered with H% tone, the speaker is more anxious to know the answer, compared with ANAQs without *ne*. This is why Shao (1996) argues that the semantics of *ne* reinforces the interrogative force. We believe that this reinforcing meaning is not due to *ne*, but due to the H% boundary tone. Following Bartels (1997) and Hara & Davis (2013), the H% tone indicates that the utterance is directed at the addressee and the speaker expects the addressee to resolve the issue. Thus, when uttering ANAQs containing *ne* with H% tone, the speaker sounds more anxious in seeking an answer. Another complexity is that whether the

(57) Semantics of ↓
$[\![\downarrow]\!] = \lambda\varphi.\lambda c.\bigcup_{x=1}^{n} T(c)[x] = \varphi$ or $\emptyset$,
where $n = |T(c)|$

Thus, when an ANAQ (i.e., *p-or-not-p*) is uttered with ↓, it expresses that the Table has no issue or that only issue on the Table is $\{p, \neg p\}$.

7 Deriving the distribution

Let us illustrate how our notion of contextual bias (47), repeated here as (58), together with the notion 'pushing an issue on the Table' (44), repeated here as (59), correctly predicts the felicity of MAQs and ANAQs in different contexts.

(58) Contextual bias (final version)
A context c is biased towards a proposition p iff
$\{p\} \subseteq \bigcup_{x=1}^{n} T(c)[x]$ and $\{\neg p\} \nsubseteq \bigcup_{x=1}^{n} T(c)[x]$,
where $n = |T(c)|$.

(59) Pushing an issue onto the Table:
If $\text{CG}(c') = \text{CG}(c) \cup (\exists x.x \in A(c)$ & $\text{Cred}_x(p) > 0)$,
Then $T(c') = \text{push}(\{p\}, T(c))$.
where c' and c are the output context and input context respectively and $A(c)$ is the set of epistemic agents at c.

7.1 Positive/Negative *ma* questions

As summarized in Section 2, +MAQs and −MAQs are in complementary distribution. Recall that a $\neg p$-*ma* has a specific felicity condition (52) that dictates that the Table must contain the issue $\{\neg p\}$. On the other hand, positive MAQs do not have such a contextual requirement. MAQs. That is, *p-ma* is unacceptable when the context is biased towards $\neg p$ while it is acceptable when the context is neutral or biased towards p. We show in this section that the distribution is straightforwardly explained in terms of pragmatic competition.

particle *ne* carries the final H% or L% depends on the lexical tone of the previous syllable. Thus, in (i) when the previous syllable carries a high level lexical tone (55), the particle *ne* cannot carry a H%.

(i) Kai55 bu kai55 chuang55 ne?
open not open window ne
'Shall we open the window or not?'

7.1.1 Neutral context

In (60), there is no issue on the Table, thus −MAQ is ruled out, while +MAQ, which does not have such an extra condition, is okay:

(60) The first question in a questionnaire investigating the relationship between weather and people's mental states is:

Q: Ni de chengshi zuotian xia yu le ma?
you GEN city yesterday fall rain PERF ma
'Did it rain yesterday in your city?' (+MAQ)

Q′: # Ni de chengshi zuotian mei xia yu ma?
you GEN city yesterday NEG fall rain ma
'Did it not rain yesterday in your city?' (−MAQ)

7.1.2 positively biased context

As shown in (31), repeated here as (61), A has asserted the proposition *p It rained*. That is, $\text{CG}(c') = \text{CG}(c) \cup (\text{Cred}_{\text{A}}(p) \geqslant 0.98)$, hence the issue $\{p\}$ is pushed onto the Table and the context is biased towards p. A default +MAQ is felicitous in such a positively biased context. In contrast, *¬p-ma* is infelicitous since unlike +MAQs, −MAQs have a contextual requirement that the context needs to be negatively biased.

(61) A: Zuowan xia yu le.
'It rained last night.'

B: Xia yu le ma?
fall rain PERF ma
'Did it rain?' (+MAQ)

B': # Mei xia yu ma?
NEG fall rain ma
'Did it not rain?' (−MAQ)

The assertion of bare p is not the only way to mark the context as biased towards p, but a modalized or embedded p as in A1–A3 of (62) is enough to make the context p-biased. Recall from the definition of 'pushing an issue onto the Table' (44) that p is pushed onto the Table as long as there is some individual x, who is not necessarily a conversation participant, that entertains the possibility of p ($\exists x.x \in A(c)$ & $\text{Cred}_x(p) > 0$). Thus, since all the A-utterances in (62) make the context biased towards p, only the +MAQ is felicitous:

(62) A1: Zuowan keneng xia yu le.
yesterday possible fall rain PERF
'Maybe it rained last night.'
A2: Wo juede zuowan xia yu le.
I think last.night fall rain PERF
'I think that it rained last night.'
A3: John shuo zuowan xia yu le.
John said last.night fall rain PERF
'John said that it rained last night.'
B: Xia yu le ma?
fall rain PERF ma
'Did it rain?' (+MAQ)
B': # Mei xia yu ma?
NEG fall rain ma
'Did it not rain?' (−MAQ)

Similarly, in (63) the contextually compelling evidence pushes p onto the Table (see (46) and (59)), thus the context is biased towards p and *p-ma* is okay while $\neg p$*-ma* is unacceptable:

(63) B enters A's windowless room wearing a wet raincoat.
A: Xia yu le ma?
fall rain PERF ma
'Did it rain?' (+MAQ)
A′: # Mei xia yu ma?
NEG fall rain ma
'Did it not rain?' (−MAQ)

In short, a −MAQ cannot be used in neutral nor positively biased contexts as it has a felicity condition that requires negatively biased contexts. A +MAQ does not have such a requirement, thus it is a default polar question that can be used in both neutral and positively biased contexts.

7.1.3 negatively biased contexts

Now, let us look at the contexts where −MAQs are used. As long as the context suggests that someone entertains the possibility of $\neg p$ as in the following, $\neg p$ is pushed onto the Table and the context is biased towards p. Since this is the

context that the felicity condition of ¬*p*-*ma* (52) requires, −MAQ wins over +MAQ as a result of pragmatic competition:

(64) A1: Zuowan (keneng) mei xia yu.
last-night possible NEG fall rain
'(Maybe) it did not rain last night.'

A2: Wo bu juede zuowan xia yu le.
I NEG think last-night fall rain PERF
'I don't think that it rained last night.'

A3: John shuo zuowan mei xia yu.
John say last-night NEG fall rain
'John said that it did not rain last night.'

B: Mei xia yu ma?
NEG fall rain ma
'Did it not rain?' (−MAQ)

B′: # Xia yu le ma?
fall rain PERF ma
'Did it rain?' (+MAQ)

Similarly, when the contextually compelling evidence supports ¬*p*, ¬*p* is pushed onto the Table, thus the context is biased towards ¬*p*. Thus, ¬*p*-*ma* is acceptable, while *p*-*ma* is not:

(65) B leaves A's windowless room carrying a raincoat. When B returns, A notices that B's raincoat is dry.

A: Mei xia yu ma?
NEG fall rain ma
'Did it not rain?' (−MAQ)

A′: # Xia yu le ma?
fall rain PERF ma
'Did it rain?' (+MAQ)

Furthermore, the felicity condition of −MAQ (52) accounts for the availability of the negative MAQ in (66), which is translated from the English example used by Romero & Han (2004) to show that English low negative questions can convey the speaker's epistemic neutrality towards answers.

(66) The speaker is organizing a party and she is in charge of supplying all the non-alcoholic beverages for teetotalers. The speaker is going through a list of people that are invited. She has no previous belief or expectation about their drinking habits.

A: Jane he Mary bu hejiu.
Jane and Mary NEG drink-alchol
'Jane and Mary do not drink.'

S: Haode. Bill ne? Ta (ye) bu hejiu ma?
good-ATTR Bill ne? 3SG too NEG drink-alchol ma
'OK. What about Bill? Does he not drink (either)?' (−MAQ)

In (66), the goal of the discourse is to '[supply] non-alcoholic beverages' and A has asserted '*Jane and Mary do not drink*', thus we can infer that the current question under discussion is a negative *wh*-question 'Who does not drink?'. This means that what is on the Table is the issue, {¬drink(j), ¬drink(m), ¬drink(b)}. Then, A's assertion pushes ¬drink(j) and ¬drink(m) onto the Table. Therefore, $\bigcup_{x=1}^{3} T(c)[x] = T(c)[1] \cup T(c)[2] \cup T(c)[3]$ = {¬drink(m)} ∪ {¬drink(j)} ∪ {¬drink(j), ¬drink(m), ¬drink(b), ...} = {¬drink(j), ¬drink(m), ¬drink(b), ...}.[9] The resulting Table contains ¬drink(b) but not drink(b). Thus, the context is biased towards ¬drink(b), even though the speaker does not have any epistemic bias. Since our definition only requires the context, not the spaker, to be biased, it correctly predicts the use of the negative MAQ in (66) to be felicitous.

In contrast, a negative MAQ is infelicitous in (67), where the goal of the conversation is now to find out who drinks. The context is biased towards p rather than $\neg p$, thus a −MAQ cannot be used.

(67) The speaker is organizing a party and she is in charge of supplying all the alcoholic beverages for (alcoholic) drinkers. The speaker is going through a list of people that are invited. She has no previous belief or expectation about their drinking habits.

S: # John bu hejiu ma?
John NEG drink-alchol ma
' Does John not drink?' (−MAQ)

In summary, we explain the complementary distribution of positive and negative MAQs summarized in Table 5 in terms of pragmatic competition.

[9] We could also treat S's utterance of *Haode* 'OK' as an acceptance of A's assertion, thus ¬drink(j) and ¬drink(m) may be already removed from the Table.

Table 5: Distribution of positive and negative MAQs

	neutral	biased towards p	biased towards $\neg p$
positive MAQs	✓	✓	#
negative MAQs	#	#	✓

The felicity condition of −MAQs (52) plays a crucial role. A −MAQ has a more specific condition that the context has to be negatively biased. Thus, whenever this rule applies, −MAQs win over +MAQs, which are uttered elsewhere, i.e., in neutral and positively biased contexts. We do not need to stipulate any contextual requirement for +MAQs, which are default polar questions. Note also that our definition allows us to uniformly deal with bias arising from default assertions, contextual compelling evidence and possibility claims.

7.2 A-not-A questions

Let us finally turn to ANAQs. As summarized in Table 6, ANAQs are only available in neutral contexts.

Table 6: ANAQs in neutral contexts

	neutral	biased towards p	biased towards $\neg p$
ANAQs	✓	#	#

In Section 5.2, we define contextual neutrality as in (68). The context is neutral with respect to p when the Table is empty or the Table contains the issue $\{p, \neg p\}$.

(68) The context c is neutral with respect to p iff $\bigcup_{x=1}^{n} \mathrm{T}(c)[x] = \emptyset$ or $\{p, \neg p\} \subseteq \bigcup_{x=1}^{n} \mathrm{T}(c)[x]$,
where $n = |T(c)|$.

Now as discussed in Section 6.2, an ANAQ is always uttered with the boundary tone ↓/L%, which denotes that all the issues on the Table amount to the Hamblin set denoted by the A-not-A construction or that an empty set:

(69) Semantics of ↓
$[\![\downarrow]\!] = \lambda\varphi.\lambda c. \bigcup_{x=1}^{n} T(c)[x] = \varphi$ or $\emptyset$,
where $n = |T(c)|$

As can be seen from (68) and (69), the presence of ↓/L% is the source of the neutrality requirement of ANAQs. The intonational morpheme, an exhaustive operator, semantically marks that the context is neutral.

Let us look at specific examples starting with neutral contexts. The context can be neutral in two ways. First, an out-of-the-blue context like (70) is a neutral context, i.e., the Table is empty ($\bigcup_{x=1}^{1} T(c)[x] = \emptyset$):

(70) A researcher uses a questionnaire to investigate the relationship between the weather and people's mental states.

Q: Ni de chengshi zuotian xia mei xia yu?↓
you GEN city yesterday fall NEG fall rain
'Did it rain or not rain yesterday in your city?' (ANAQ)

Second, the context is neutral when both issues, $\{p\}$ and $\{\neg p\}$, are on the Table. In (71), A and B's assertions push p and $\neg p$ onto the Table, respectively. Thus, at the context after B's assertion, the Table contains both issues ($\bigcup_{x=0}^{2} T(c)[x] = \{p\} \cup \{\neg p\} = \{p, \neg p\}$). Thus, according to (68), the context is neutral and compatible with the semantics of ↓.[10]

(71) A: Zuowan xia yu le.
'It rained last night.'

B: Bu, meiyou xia.
'No, it did not rain.'

C: (Suoyi / Daodi) xia mei xia yu?↓
so after.all fall not fall rain
'(So/After all,) Did it rain or not rain?' (ANAQ)

[10] One may wonder whether it is better to separate unmarked ANAQs from ones marked with the adverb *daodi* as the one in (71) since the $\{p, \neg p\}$ part in the definition of contextual neutrality in (68) seems to be needed only for *daodi* ANAQs. However, providing independent definitions for unmarked ANAQs and *daodi* questions would not only fail to capture the apparent overlaps in their syntactic structures and meanings but also such definitions would be inconsistent with each other. Suppose that the neutrality requirement for unmarked ANAQs is only that there be no issues on the Table. On the other hand, the adverb *daodi* presupposes that the question it attaches to is an old question (i.e., the question has already been pushed onto the Table but not solved), so the speaker uses *daodi* questions to urge the addressee to provide the answer immediately, yielding what Biezma (2009) calls the cornering effect. As can be seen, the composition would result in contradiction of the two presuppositions: The A-not-A construction presupposes that there is no issue while *daodi* presupposes that the issue denoted by the prejacent is already on the Table. We thus consider both having no issues, $\emptyset$, and having a polar issue, $\{p, \neg p\}$, as cases of contextual neutrality.

When the context is biased toward p by an assertion of p as in (72), the Table contains $\{p\}$, i.e., $\bigcup_{x=0}^{1} \mathrm{T}(c)[x] = \{p\}$, but not $\{\neg p\}$. Therefore, the context contradicts the semantics of ↓.

(72) A: Zuowan xia yu le.
'It rained last night.'
B: # Xia mei xia yu?↓
'Did it rain or not rain?' (ANAQ)

Similarly, when someone asserts $\neg p$, the context is biased towards $\neg p$ as in (73). Then, the Table contains $\{\neg p\}$, but not $\{p\}$, and becomes incompatible with the semantics of L%.

(73) A: Zuowan mei xia yu.
'It did not rain last night.'
B: # Xia mei xia yu?↓
'Did it rain or not rain?' (ANAQ)

In all other positively and negatively biased contexts discussed in Section 7.1.2 and Section 7.1.3, respectively, an ANAQ is infelicitous. The same explanation applies: The Table contains only either $\{p\}$ or $\{\neg p\}$ and not the issue with the opposite polarity, which conflicts with the semantics of ↓.[11]

In short, an ANAQ can be uttered only in neutral contexts because the intonational morpheme ↓ that is obligatorily present in the ANAQ semantically expresses that the context is neutral.

[11] An anonymous reviewer points out that the utterance of *maybe p*, which is supposed to give rise to a positively biased context as seen in (62), can be followed by the phrase *Shuo qingchu dian!* 'Please be clear!' and a *daodi* ANAQ:

(i) A: Zuowan keneng xiayu-le.
last.night possible rain-ASP
'Maybe it rained last night.'
B: (Shuo qingchu dian!) Zuowan (daodi) xia mei xiayu?
say clear a.bit last.night after.all rain not rain
'(Please be clear!) Did it rain last night or not?'

We speculate that the issue that the utterance of *maybe p* raises is $\{p\}$ by default but it could be $\{p, \neg p\}$. Our speculation is motivated by the fact that the presence of the phrase *Shuo qingchu dian!* 'Please be clear!' and the adverb *daodi* in (i) are crucial since B's utterance of ANAQ becomes infelicitous without them:

(ii) A: Zuowan keneng xiayu-le.
'Maybe it rained last night'

8 Concluding remarks

The differences among the three kinds of polar questions, +MAQs, −MAQs and ANAQs, discussed in this paper are very subtle. As argued by Yuan & Hara (2019), they all create a Hamblin issue and push it onto the conversation Table. Previous researchers were also aware that these questions convey different bias meanings, and attempted to characterize the semantics of these questions in terms of the speaker's bias. In this paper, we show that the speaker's bias is not suitable to account for their distribution. Instead, we argue that the contextual bias determines the landscape of Mandarin polar questions. The notion of the contextual bias is formalized in terms of subjective probability and Farkas & Bruce's (2010) Table model. The context is biased towards p when it is a common belief that some individual entertains the possibility of p and there is no individual that publicly entertains the possibility of $\neg p$. Our formalization can correctly predict not only the biases that arise from the previous assertions in the discourse but also the ones that arise from non-verbal, contextually-compelling evidence, low-possibility claims, and reported assertions made by non-participants.

Our analysis also has important theoretical implications in the interfaces among prosody, semantics and pragmatics. First, by employing the elsewhere condition to explain the division of labor of +/−MAQs, we can maintain a simple semantics for -MAQs and there is no need to stipulate felicity conditions for +MAQ. Second, the current analysis supports the idea that a prosodic contour such as ↓/L% is an intonational morpheme that can bear semantic content that affects the grammaticality of the construction.

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B: # Zuowan xia mei xiayu?
'Did it rain last night or not?'

The contrast between (i) and (ii) shows that *Shuo qingchu dian!* and *daodi* presuppose that there is an unsolved issue $\{p, \neg p\}$ on the Table, though the presupposition is not explicitly spelled out in (i). Thus, the use of *Shuo qingchu dian!* and *daodi* coerces the contextual update of uttering '*maybe p*' from pushing $\{p\}$ onto the Table to pushing $\{p, \neg p\}$. This coercion is reasonable given the semantics of existential modal in awareness semantics. The precise semantics of *maybe*/*keneng* is beyond the scope of the paper, but in awareness semantics (Crone 2018, Bledin & Rawlins 2020), '*maybe p*' translates to 'an agent is aware of p'. Furthermore, if an agent is aware of p, she is also aware of $\neg p$.

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