

Wh-Questions on the Table
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Abstract: Farkas and Bruce (2010) propose a model that treats assertions and polar questions as moves on the Table where information is negotiated before common ground update. Their model is restricted to polar questions although many interesting potential applications extend to constituent questions. The key problem, it turns out, is to keep a balance between logically exhaustive answers and partial answers (more realistic but logically problematic). I propose that the speaker, in asking a *wh*-question, aims to achieve a discourse state where the common ground has been updated by an *relevant-exhaustive answer*. This analysis allows a pragmatically realistic analysis of question-answer dialogues and lays the ground to extend the Table model to constituent questions. I define the operations to treat both relevant-exhaustive and partial answers as moves on the Table. Finally, the resulting tool kit is demonstrated to be indispensable if we want to investigate Questions under Discussion as Questions on the Table.

Introduction

Farkas and Bruce (2010, henceforth [FB]) propose a discourse model that treats assertions, polar questions and answers to polar questions as manipulations of the common ground CG and public belief sets for each interlocutor. Utterances are put on the table and require further reactions according to the rules of the language game. The game reaches a stable state once all utterances have been cleared from the table. While Farkas and Bruce were mainly interested in confirmative and reversing reactions to assertions and questions, their model proved fruitful in later research and was adapted for a wide variety of new purposes, such as in (Faller 2015) for reportatives, (Ettinger and Malamud 2014) for the Mandarin particle *ba*, (Gutzmann, Hartmann and Matthewson 2016) on Verum Focus in Gizkan, (Castroviejo et al. 2013) for presupposition rejection and accommodation, (Torregossa 2015) for contrasts on the table, (Gärtner 2012) to analyse the quotative modal *wollen*, and (Hogeweg 2011) for German and Dutch *doch/toch*, among others.

The range of possible applications is however limited by the fact that the account is restricted to polar questions. We still need an Extended Table Model for *constituent questions* and answers as moves on the table. Such a model is particularly desirable for Farkas and Bruce as they see their model as a potential implementation of Questions under Discussion (QuD) in the sense of (Roberts 1996), (Büring 2003) and (Ginzburg 1996) ([FB]:86). Given that the Question under Discussion is typically a constituent question, this part of Farkas and Bruce's research agenda remains unexplored unless the basic model is extended to constituent questions. The present paper proposes an Extended Table Model for *wh*-questions and explores the pragmatics of various types of answers.

The paper is organized as follows. Section 1 surveys the basic data in question-answer dialogues. Section 2 recapitulates [FB]'s model and surveys first ideas to extend the model to *wh*-questions. I argue that a naïve extension would fail because natural question-answer dialogues are not as exhaustive as semantic theory would require. Section 3 proposes the basics for remedy. Questions in everyday communication request *helpful* answers rather than exhaustive answers. Answers are often given with the tacit afterthought "...and this is all you need to know." We introduce the notion of information being RELEVANT for the questioner and the notion of a *relevant-exhaustive* answer. Based on these notions, Section 4 defines the Extended Table Model for *wh*-questions and demonstrates its predictions for dialogues with questions

and relevant-exhaustive answers. Section 5 explores dialogues where questions receive partial answers. Several partial answers are accumulated to an exhaustive answer before the question can be removed from the table. Assertions can be marked as partial answers in various ways and the analysis correctly predicts that they all create an obligation for the interlocutors to pursue the Question under Debate further. Section 6 summarizes.

1. Questions as moves in the language game

Let us survey possible exchanges between two speakers, consisting of a constituent question, an answer to the question and further reactions to the answer.¹ It will also be useful to classify questions according to their logic and pragmatics. Some *wh*-questions have mutually exclusive answers and each possible answer is thus an exhaustive answer. Other *wh*-questions have simple answers that are not exhaustive and not mutually exclusive—several of them can be true together. Questions can moreover be uttered as requests for an exhaustive answer or as a request for a non-exhaustive (mention-some) answer. Farkas & Bruce restricted attention to polar questions; these are logically simple in that they have just two answers, which are each exhaustive and mutually exclusive. The Extended Table Model should capture all possible types of question-answer dialogue.

1.1 Questions with a unique true answer

The simplest type of constituent question is exemplified in (1).

(1) *Where is the car key?*

A true answer to (1) automatically excludes all other possible answers, hence each answer is an exhaustive answer, as illustrated in (2). The answers are generated by replacing the *wh*-constituent by a phrase of matching syntactic category. We will call such answers *simple answers* in the following.

(2) *'the key is in the kitchen'*
'the key is in the bathroom'
'the key is in my jacket' ...

Assume that question (1) is asked by speaker A addressing speaker B. This invites an answer by the addressee B to which A, in turn, can react. Different reactions are illustrated in (3.a1, 3.a2).

(3) A: *Where is the car key?*

(3.a) B: *The key is in the bathroom.*

(3.a1) A: *Ok, thanks.*

(3.a2) A: *No. (I've searched the bath and it wasn't there.)*

In (3.a1) A accepts B's assertion. In (3.a2), A rejects the assertion and the dialogue enters into what Farkas and Bruce call a 'crisis'. We disregard the case where B refuses to answer. In such a situation it is up to speaker A whether the question remains on the table and whether alternative ways to find an answer should be pursued.

¹ This setup parallels Farkas and Bruce's data for assertions and polar questions.

1.2 Questions with more than one simple answer

Questions like (4) have several simple answers that are logically compatible.

(4) A: *Who wants coffee?*

Talking about the group of Al, Bertha and Chris, any combination of simple answers can be true:

(5) *'Al wants coffee'*
'Bertha wants coffee'
'Chris wants coffee'
'Al and Bertha want coffee'

...

Depending on the utterance situation, A can request an exhaustive answer or a non-exhaustive answer. If A plans to get coffee for everyone, A plausibly requests a complete list of true assertions of the form 'X wants coffee' where X ranges over the set of contextually salient persons.

(5.a) B: *Al wants coffee and Chris wants coffee.*

When B falls silent, A will normally interpret this as exhaustification: '*...and nobody else wants coffee*'. As long as A remains silent, the interlocutors will understand that A accepts B's answers and they can update the common ground. Farkas and Bruce's model allows to interpret silence as a move in discourse (see Section 2) and we will see more instances of meaningful silence here.

In other kinds of situations, A can ask a question and request a non-exhaustive answer. These situations differ from the earlier dialogues in that A has more options to challenge B's answers. Here is an example.

(6) A: *Where can I buy the Times?*

(6.a) B: *At the harbour in Staad.*

In this situation, B's falling silent does not signal that (6.a) is an exhaustive answer to A's question. A can accept B's answer, A can challenge the truth of B's answer, but A can also challenge B in a different way, as shown in (6.a3).

(6.a1) A: *Ok.*

(6.a2) A: *That's not true. (I asked them and they do not sell it.)*

(6.a3) A: *Hm. Any other places?*

Given that B's answer is not an exhaustive answer, both reactions in (6.a2) and (6.a3) signal that the question is still open and that A hopes for more information. (6.a2) constitutes what [FB] call a 'crisis' with the possible interim result that A and B agree that they disagree on the truth of (6.a). It is not immediately clear whether (6.a3) also constitutes a crisis in dialogue. While A and B do not disagree on the truth of '*You can buy the Times in Staad*', they disagree at a meta level: While B thinks that this answer can settle the question, A is not yet satisfied. We will see how this type of crisis can be captured.

1.3 *Partial information*

In our test dialogues so far, B always seems to suggest that the question can now be removed from the table. However, B can also use distinct linguistic means to signal that the question should be pursued further.

- (7) (A: *What laudable properties does Ms. Smith have?*)
B: *Ms. Smith is not only a brilliant mathematician.*

The assertion in (7) addresses an explicit or implicit question about laudable properties of Ms. Smith. B's assertion answers this question but it is not a felicitous closing line. The speaker is required to add further laudable properties of Ms. Smith. Existing pragmatic theories predict that (7) is uttered against alternative salient properties of Ms. Smith (association with focus, Rooth 1985, Beaver & Clark 2008) and plausibly answers the QuD "*Which laudable properties does Ms. Smith have?*" Yet, there is to date no formal theory that predicts that (7) can not close a discourse.²

Similar obligations to continue the search for an answer can be created by speakers who indicate a strategy (Roberts 1996, Büring 2003).

- (8) A: *Who can feed the cat next week?*
B: [*I*]_{CT} *am* [*on vacation*]_F.

Authors agree that B offers a partial answer to the question "*Who is where next week?*" and thereby signals that this question should be exhaustively explored before A will find an answer to his more specific question. An analysis of Questions on the Table must cover partial answers and questions that remain open.

In summary, an analysis of questions on the table must capture the following data:

- Questions can be requests for exhaustive or for mention-some answers. Both have to be captured. In particular, exhaustive answers are not the default and are excluded as uncooperative in many situations
- The responder can signal that the answer is considered sufficient.
- The questioner can accept or challenge an answer, but can also ask for further information, thereby signalling that the answer was not (yet) sufficient.
- Answers can be linguistically marked as partial. A question model must predict that the current question is still open and the discourse has not reached a stable state.

The next section summarizes the basic account by Farkas and Bruce (2010) and explores a naïve extension to *wh*-questions on the table. I argue that the naïve extension is inadequate and that new ideas are needed in order to get a working account for *wh*-questions and answers.

2. Farkas and Bruce (2010)

2.1 *The basic model*

According to [FB], a dialogue between speakers A and B is represented by a context K that includes the common ground CG, the discourse commitments DC_A, DC_B of the interlocutors, the Table (where currently active utterances are stored) and the

² To be precise, a theory should predict that (7) can only close a conversation under very special circumstances, for instance to summarize earlier findings.

projected set PS.³ If A puts an utterance S on the Table, this requires some reaction by interlocutor B. A and B negotiate until they agree on a shared knowledge state (including the possibility that they agree to disagree on certain points). Then the utterance S is taken off the Table and the dialogue has reached a stable state. If A makes an assertion, B can accept or reject it. If A asks a question, B can assert an answer which, in turn, offers A new options to react. In this section, I list the main rules of Farkas and Bruce (with their number in that paper) for further reference.

Farkas and Bruce point out that reactions in the language game can be minimal. For instance, tacit consent often suffices for B to accept an assertion made by A. In order to capture *default outcomes* a discourse move, [FB] include the projected set PS. The projected set takes the current CG as its starting point and reflects the possible default outcome(s) of the on-going dialogue.

Let us begin with [FB]'s assertion rule (9) (p. 92). It states that if A opens the conversation by making assertion S in context K_1 , the context gets updated as follows (K_2 being the output context). For a start, we assume that the initial projected set $PS_1 = \{ CG_1 \}$.

Putting an assertion on the table [FB 9]

- i. $[[S]]$ is added to the discourse commitments of A
 $DC_{A,2} := DC_{A,1} \cup \{ [[S]]$ }
- ii. the sentence-meaning pair $\langle S, [[S]]$ \rangle is added to the top of the Table
 $T_2 := \text{push}(\langle S, [[S]]$ $\rangle, T_1)$
- iii. the projected set anticipates that, by default, A's claim will be added to the common ground: $PS_2 = \{ CG_1 \cup \{ [[S]]$ $\}$
- iv. the discourse commitments of B as well as the common ground CG_1 remain unchanged.

The updated PS_2 in (iii) records the default result that speaker A aims at: $[[S]]$ should update the common ground. To account for contexts with a more complex PS, we need [FB]'s pointwise update operation.

Let $PS = \{ C_1, C_2, \dots, C_n \}$ be a set of sets of propositions and let $P = \{ p_1, \dots, p_m \}$ a set of propositions. The pointwise update of PS by P is defined as

$$(9) \quad PS \cup^* P := \{ C_i \cup \{ p_j \} \mid i \leq n, j \leq m \} - \{ C_i \cup \{ p_j \} \mid C_i \models \neg p_j \}$$

That is, we collect all possible extensions of a C_i by some p_j except those where the update would be inconsistent. The general version of [FB 9] hence has

$$\text{iii.} \quad PS_2 := PS_1 \cup^* \{ [[S]]$$
 $\}$

In the following, we use this general version. The next operation formalizes B's tacit consent. It states that, by doing nothing, B is committed to take over A's belief.

Assertion confirmation [FB 16]

- i. The input context K_1 has $\langle S, [[S]]$ \rangle on top of the table, and $[[S]]$ is part of the discourse commitments of A: $[[S]]$ $\in DC_{A,1}$.
- ii. K_2 has $DC_{B,2} := DC_{B,1} \cup \{ [[S]]$ $\}$
- iii. K_2 adopts all other components from K_1 .

³ We will restrict attention to two-speaker dialogue to keep matters simple. Multi-speaker conversations play a role in Section 5.

Let us next look at the rule for speaker A bringing up a polar question. A aims at an update of the current CG by the true answer to Q. The rule for polar questions [FB (12)] reflects this. The context K_1 is changed into K_2 in the following way:⁴

Putting a polar question on the table [FB 12]

- i. The question and its meaning are put on the table
 $T_2 := \text{push}(\langle Q, [[Q]] \rangle, T_1)$ with $[[Q]] = \{p, \neg p\}$.
- ii. The projected set reflects that both answers to Q are possible results of the dialogue and that none of them is adopted by default.
 $PS_2 := PS_1 \cup^* \{p, \neg p\}$
- iii. The discourse commitments of A, B and the common ground CG_1 remain unchanged.

In the simplest case, $PS_1 = \{CG_1\}$ and the pointwise update yields $\{CG_1 \cup \{p\}, CG_1 \cup \{\neg p\}\}$. Here we see the two possible direction that the on-going discourse can take.

Let us process a simple question-answer dialogue in the [FB] model to see its effects. We assume K_0 a context in a stable state where T_0 , $DC_{A,0}$ and $DC_{B,0}$ are empty. A and B share some common ground CG_0 . The projected set $PS_0 = \{CG_0\}$ shows that there are no current options to update CG_0 . Here we go.

- (10) A: *Do you want coffee?*
 B: *No. (I don't want coffee.)*

After A's question, the context will be updated to K_1 in (11) where $p =$

$[[B \text{ wants coffee }]]$. $CG_1 = CG_0$ as no update has taken place.

- (11) K_1

A	Table	B
$DC_{A,1} -$	$\langle \text{do you want coffee?}; \{p, \neg p\} \rangle$	$DC_{B,1} -$
CG_1	$PS_1 = \{CG_0 \cup \{p\}, CG_0 \cup \{\neg p\}\}$	

After B's response, B is committed to the proposition $\neg p$. The default result of the dialogue is one where the question is settled and B's response is accepted. But A is still uncommitted and the CG_2 remains the same as before.

- (12) K_2

A	Table	B
$DC_{A,2} -$	$\langle \text{do you want coffee?}; \{p, \neg p\} \rangle$ $\langle \text{No. } \{\neg p\} \rangle$	$DC_{B,2} = \{\neg p\}$
CG_2	$PS_2 = \{CG_0 \cup \{\neg p\}\}$	

PS_2 is computed as follows:

⁴ FB represent assertions and questions by sentential root S, plus force D (declarative) or I (interrogative). This allows them to trace whether S contains a negation, which in turn is crucial for reversing and confirming reactions. The present paper adopts the standard notation for sentences and meanings. For a discussion of negation see Section 4.

$$\begin{aligned} PS_2 &= PS_1 \cup^* \{ \neg p \} = \{ CG_1 \cup \{ p \} \cup \{ \neg p \}, CG_1 \cup \{ \neg p \} \cup \{ \neg p \} \} \\ &= \{ CG_1 \cup \{ \neg p \} \} \end{aligned}$$

The resulting projected set successfully mirrors that the default outcome of the conversation at this point is one where the common ground CG_0 gets updated by B's answer. The second alternative outcome, $CG_0 \cup \{ p \}$, has been discarded because it was incompatible with B's answer.

Finally, silence (or nodding consent) by A is interpreted by adding B's answer to A's discourse commitments DC_A . No other changes occur.

(13) K_3

A	Table	B
$DC_{A,3} = \{ \neg p \}$	$\langle do\ you\ want\ coffee?; \{ p, \neg p \} \rangle$ $\langle No. \{ \neg p \} \rangle$	$DC_{B,2} = \{ \neg p \}$
CG_3		$PS_3 = \{ CG_0 \cup \{ \neg p \} \}$

As soon as A and B have the shared public commitment $\neg p$ in discourse, $\neg p$ gets removed from DC_A , DC_B and added to the common ground. All items that "involve" $\neg p$ in their meaning are removed from the table.

We have not introduced the corresponding rule as yet. This is [FB]'s rule (17) for clearing the table.

Clearing the table [FB 17]

As soon as the discourse commitments of A and B have non-empty intersection: $p \in DC_{A,n}$ and $p \in DC_{B,n}$, the context K_n is changed in the following ways:

- i. $CG_{n+1} := CG_n \cup \{ p \}$ update of common ground
- ii. $DC_{A,n+1} := DC_{A,n} \setminus \{ p \}$ downdate of A's commitments
 $DC_{B,n+1} := DC_{B,n} \setminus \{ p \}$ downdate of B's commitments
- iii. If an assertion $\langle S, [[S]] \rangle$ is on table T_n and CG_{n+1} entails $[[S]]$, then $\langle S, [[S]] \rangle$ is removed from the table.
- iv. If a question $\langle Q, [[Q]] \rangle$ is on the table T_n and CG_{n+1} entails some $q \in [[Q]]$, then $\langle Q, [[Q]] \rangle$ is removed from the table.

As a result, the new table T_{n+1} is T_n , downdated by all assertions and questions that are entailed or answered by the new information p in CG .

In the present example, this leads to the empty table (14).

(14) K_4

A	Table T	B
$DC_{A,4} -$	-	$DC_{B,4} -$
$CG_4 = CG_0 \cup \{ \neg p \}$		$PS_4 = \{ CG_0 \cup \{ \neg p \} \} = \{ CG_4 \}$

The context $\langle CG, DC_A, DC_B, T, PS \rangle$ is in a stable state if all shared beliefs have been moved to the common ground, the table is empty and the PS contains just the CG (which could be paraphrased as: "there are no open suggestions to change the CG").

- i. $DC_A \cap DC_B = \emptyset$

- ii. $T = \emptyset$
- iii. $PS = \{CG\}$

All dialogues are driven by the shared aim of the interlocutors to reach a stable state.

2.2 *A naïve extension to wh-questions?*

At first glance, the basic model seems to host *wh*-questions without further changes. Rule [FB 12] for polar questions would also make sense for *wh*-questions. If we used [FB 12] to put a *wh*-question on the table, we would cause a change of the projected set PS_1 to PS_2 which would be a pointwise update of PS_1 by all possible answers to Q . The meaning of question Q is standardly taken to be the set of all possible answers to Q . Hence we would get

$$PS_2 := PS_1 \cup^* [[Q]]$$

If speaker B offers an assertion S in response to Q , we could again naively propose that B's utterance S be processed like assertions by [FB 9]. The basic model predicts the following effects:

- i. $[[S]]$ becomes part of DC_B of speaker B
- ii. $\langle S, [[S]] \rangle$ is pushed on the Table
- iii. PS_2 is updated pointwise by $[[S]]$: $PS_3 = PS_2 \cup^* \{ [[S]] \}$

While these operations would be well-defined, they do not yield satisfactory results. To see this, let us discuss a simple example, the question *Who wants coffee?* For a start, we must choose a specific format for the semantic representation of questions. According to the most widely adopted account, the meaning of a question Q consists of the set of all *exhaustive* possible answers p to Q (Hintikka 1975, Karttunen 1977, Groendijk and Stokhof 1984a,b, Groenendijk 2003). For example, the question *Who wants coffee* receives the representation in (15).

$$(15) \quad [[Who\ wants\ coffee?]] = \{ \begin{array}{l} \text{'Ann wants coffee, and no one else does'}, \\ \text{'Ann and Bertha want coffee and no one else does'}, \\ \text{'Ann and Bertha and Chris want coffee and no one else does'}, \\ \text{'Bertha and Chris want coffee and no one else does'}, \\ \text{'Chris wants coffee and no one else does', ...} \end{array} \}$$

Following the alternative view in (Hamblin 1973), the meaning of a question is the set of all simple answers to the question—answers that arise by replacing the question pronoun by constants that range over the relevant domain.⁵ In this framework, the question *Who wants coffee* receives the meaning in (16).

$$(16) \quad [[Who\ wants\ coffee?]] = \{ \text{'Ann wants coffee'}, \text{'Bertha wants coffee'}, \text{'Chris wants coffee'} \}$$

The two accounts make identical predictions for questions Q with mutually exclusive simple answers (as the car key question in (1)) as well as for Polar Questions (Farkas & Bruce 2010). Yet, the Extended Table Model must cover more types of question-answer dialogue.

⁵ For an implementation see (Eckardt 2007).

Let us add a second example where the speaker asks for a non-exhaustive answer.

- (17) $[[\textit{Where can I buy the Times?}]]$ =
 {‘A can buy the Times in Staad’, ‘A can buy the Times at the university kiosk’, ‘A can buy the Times at the train station’, ‘A can buy the Times at the harbour’, ‘A can buy the Times at Karstadt’, ... }

Hamblin question semantics

- (18) $[[\textit{Where can I buy the Times?}]]$ =
 {‘in Staad and nowhere else’,
 ‘in Staad and at the university kiosk and nowhere else’,
 ‘in Staad and at the university kiosk and at the train station and nowhere else’,
 ‘at the university kiosk and nowhere else’, ‘at the university kiosk and at the train station and nowhere else’,
 ‘at the train station and nowhere else’,
 ‘at the harbour and nowhere else’, ... }

Groendijk-Stokhof question semantics

Next, we will explore the predictions of the naïve extended model for these two examples.

2.2.1 *Why Hamblin question semantics is problematic*

According to the [FB] model, asking a question updates the projected set such that all possible answers to the question are mirrored as possible updates of the current common ground. Consider the following dialog.

- (19) A: *Who wants coffee?*
 B: *Chris wants coffee.*

Let CG_0 be the common ground of A and B before (19). Following [FB], A’s question would change the projected set PS_0 to (20).

- (20) $PS_1 = \{ CG_0 \cup \{ a_i \} \mid a_i \in [[\textit{Who wants coffee?}]]$ }

With non-exhaustive question semantics, this amounts to the following potential update in the scenario above.⁶

$$\begin{aligned} PS_1 &= \{ CG_0 \cup \{ \textit{‘Ann wants coffee’} \}, \\ &\quad CG_0 \cup \{ \textit{‘Bertha wants coffee’} \}, \\ &\quad CG_0 \cup \{ \textit{‘Chris wants coffee’} \} \} \\ &=: \{ CG_{Ann}, CG_{Bertha}, CG_{Chris} \} \end{aligned}$$

B’s answer in (19) asserts that Chris wants coffee. Intuitively, this assertion should update PS_1 and create a context where—if A does nothing—the common ground is eventually updated by this proposition and the question counts as settled. However, this is not what the naïve extended model predicts.

$$\begin{aligned} &PS_1 \cup * \{ \textit{‘Chris wants coffee’} \} \\ &= \{ CG_{Ann} \cup \{ \textit{‘Chris wants coffee’} \}, \\ &\quad CG_{Bertha} \cup \{ \textit{‘Chris wants coffee’} \} \} \end{aligned}$$

⁶ I use English sentences in single quotes for propositions, such that ‘Ann wants coffee’ = $[[\textit{Ann wants coffee}]]$.

$$\begin{aligned} & \text{CG}_{\text{Chris}} \cup \{ \text{'Chris wants coffee'} \} \\ \text{--- } & \{ \text{CG}_X \cup \{ \text{'Chris wants coffee'} \} \mid \\ & X = \text{Ann, Bertha or Chris} \ \& \ \text{CG}_X \models \neg \text{'Chris wants coffee'} \} \end{aligned}$$

We would collect all possible updates by ‘Chris wants coffee’ and sort those out that are logically inconsistent. Given that all updates are consistent, we would end up with the PS in (21).

$$\begin{aligned} (21) \quad \text{PS}_1 \cup^* \{ \text{'Chris wants coffee'} \} = \\ & = \{ \text{CG}_1 \cup \{ \text{'Ann wants coffee'}, \text{'Chris wants coffee'} \}, \\ & \quad \text{CG}_1 \cup \{ \text{'Bertha wants coffee'}, \text{'Chris wants coffee'} \}, \\ & \quad \text{CG}_1 \cup \{ \text{'Chris wants coffee'} \} \} \end{aligned}$$

Finally, the naïve extension predicts: If A accepts B’s answer the common ground CG_1 gets updated ([FB 17]) and the question *Who wants coffee?* is removed from the table.

The resulting context would be of a kind that Farkas & Bruce never discuss. The table would be empty and suggest that the question is settled. The projected set, however, would include several directions in which the discourse could develop. This would suggest that the interlocutors are still concerned with Bertha and Ann. These options would remain open for the rest of the conversation. This is inadequate. In a stable state, the projected set should contain the current CG as the only one option for the dialogue.⁷

We could try to rescue the example by assuming that B’s answer is interpreted as an exhaustive answer: ‘*Chris wants coffee and Ann and Bertha don’t want coffee.*’ Yet, the problem would return in conversations where A asks for a non-exhaustive answer.

$$\begin{aligned} (22) \quad \text{A: } & \textit{Where can I buy the Times?} \\ & \text{B: } \textit{In Staad.} \end{aligned}$$

The default result of (22) should be a context K_3 where the common ground has been updated by ‘A can buy the Times in Staad’ and the question has been removed from the table. B’s answer in (22) should not entail that Staad is the *only* place where A can buy the Times. In the naïve extension, however, A’s question would generate the PS in (23). B’s literal answer would lead to the PS_2 in (24), and B’s answer exhaustified would result in the PS_2 in (25).⁸

$$(23) \quad \text{PS}_2 := \text{PS}_1 \cup^* \{ \text{'you can buy the Times in Staad'}, \dots \text{'you can buy the Times at the train station'} \}$$

$$\begin{aligned} (24) \quad \text{PS}_3 := & \text{PS}_2 \cup^* \{ \text{'you can buy the Times in Staad'} \} \\ = & \{ \text{CG}_1 \cup \{ \text{'you can buy the Times in Staad'}, \\ & \quad \text{CG}_1 \cup \{ \text{'you can buy the Times at the train station or in Staad'} \} \\ & \quad \dots \} \end{aligned}$$

$$(25) \quad \text{PS}_3 := \{ \text{CG}_1 \cup \{ \text{'you can buy the Times in Staad and nowhere else'} \} \}$$

Neither of these projected sets is adequate at the end of A-B’s exchange. (24) leaves too many open options. (25) is inadequate because A can consistently ask B for more

⁷ This is not added as an explicit requirement in Farkas & Bruce, due to the fact that their examples never generate projected sets and contexts such as the one here.

⁸ Assume that the conversation was initiated against empty Table T_1 in context K_1 with CG_1 .

information, which shows that A does not interpret B's answer as exhaustive even if B falls silent.

In sum, a Hamblin semantics for questions can not be used in a naïve extension of [FB]'s Table Model to *wh*-questions. Let us explore the Groendijk-Stokhof account.

2.2.2 Why Groendijk-Stokhof question semantics is problematic

Exhaustive answers are mutually logically exclusive. If we assumed an exhaustive question semantics, the coffee dialogue in (19) would be analysed adequately. These are the putative steps of computation.

(19, start) A: *Who wants coffee?*

$$\begin{aligned} \text{PS}_2 &= \{ \text{CG}_1 \cup \{ a_i \} \mid a_i \in [[\textit{Who wants coffee?}]] \} \\ &= \{ \text{CG}_1 \cup \{ \textit{'Ann wants coffee, and no one else does'} \}, \\ &\quad \text{CG}_1 \cup \{ \textit{'Bertha wants coffee, and no one else does'} \}, \\ &\quad \text{CG}_1 \cup \{ \textit{'Chris wants coffee, and no one else does'} \}, \\ &\quad \text{CG}_1 \cup \{ \textit{'Ann and Bertha want coffee, and no one else'} \} \dots \} \end{aligned}$$

(19 cont.) B: *Chris wants coffee.*

In order to interpret B's utterance as an answer in the GS sense, we would have to read it as an exhaustive answer: 'Chris wants coffee, and no one else does'. If we updated PS_1 accordingly, we would get PS_2 .

$$\begin{aligned} \text{PS}_3 &= \text{PS}_2 \cup * \{ \textit{'Chris wants coffee, and no one else does'} \} \\ &= \{ \text{CG}_1 \cup \{ \textit{'Chris wants coffee, and no one else does'} \} \} \end{aligned}$$

If A tacitly accepted B's answer, DC_A and CG would be updated and the question would be removed from the table. The resulting PS would be $\text{PS} = \{ \text{CG} \}$, which correctly reflects that no further changes of the CG would be suggested. The exhaustive question semantics yields adequate results for dialogues where the questioner requests an exhaustive answer. Moreover we see that exhaustive answers are logically nice because they keep the projected set lean and simple.

What about dialogues where a mention-some question is requested?

(26) A: *Where can I buy the Times?*

B: *In Staad.*

The exhaustive question semantics would predict that A's question denotes the set of all lists that tell for any place whether it sells the Times or not. The projected set after A's question would include all updates of the current CG by one of these answers.

The assertion of B must be matched with these. We could stipulate that

- B's answer is interpreted as an exhaustive answer.
(This is empirically inadequate.)
- B's answer is in fact a multiple answer. B delivers a disjunction of all exhaustive answers that entail 'A can buy the Times in Staad'.
(We have to explore where this leads us.)

Given that the first option is inadequate, let us pursue the second and assume that the content of B's assertion is the disjunction $\bigvee \{ a_i \mid a_i \text{ is an exhaustive answer and} \dots \}$

entails ‘A can buy the Times in Staad’ }. This disjunction is compatible with all exhaustive answers that entail ‘Staad’ as a place to buy the Times. If we pointwise updated the projected set, the resulting PS would contain *multiple* possible updates of the common ground, namely all those that include Staad as one of the possible options. This would leave us with the following questions:

- If A accepts B’s answer as true: how should the actual CG update relate to the multiple options in PS?
- The question has not, logically speaking, been answered. The clearing rule [FB 17] requires that CG entails an answer to Q but this is not the case at this point. How can the question be removed from the table?

We are a point where any reasonable next stage of context requires new *ad hoc* operations.

It would be ideal to take B’s answer for what it is: a partial answer that is sufficient for the moment. This would fit the dialogue in (26), but also matches with the possible reactions of A in (5.a), repeated below.

(5.a1) A: *Ok.* (answer accepted as true)

(5.a2) A: *That’s not true. (I asked them and they do not sell it.)*
(answer rejected as false)

(5.a3) A: *Hm. Any other places?*
(answer rejected as insufficient)

Neither of the standard semantics for questions will give us an analysis of (5.a3) for free. In the next section, I introduce the notion of a *relevant-exhaustive* answer and define the basic terms to make this idea precise.

3. The pragmatics of questions and helpful answers

According to standard assumptions, the meaning of a question Q consists of the set of answers. Yet, there is a mismatch between propositions that count as answers in the semantic sense and propositions that *resolve a question*, i.e. answers that intuitively count as helpful. The mismatch is a notorious problem for automatic question-answering systems but has also been theoretically acknowledged; most extensively in the work of (Ginzburg 1995) and (van Rooij 2003).

The Extended Table Model aims to capture questions and answers in communicative exchange. It is a pragmatic model and must therefore refer to *helpful* answers in this intuitive sense. If A asks a question in a particular situation, both A and B have an idea of A’s goals and hence both know which information might be helpful: information that answers the question and is relevant for A to achieve her goal. B chooses her answer in accordance with Grice’s Maxims of Relevance and Quantity: *Make your contribution as informative as necessary for the purpose of the exchange.* The point has been argued most extensively in (Ginzburg 1995) who introduces the notion of ‘information that *resolves* a given question relative to the goal and belief/knowledge of the questioner.’ Ginzburg demonstrates that goals and beliefs disqualify certain propositions as resolving information although the proposition, logically speaking, answers the question. In the other direction, information can be resolving that, formally, does not answer the question in either Hamblin’s or Groendijk-Stokhof’s sense. While I will not adopt Ginzburg’s analysis in all parts, his

insights are extremely valuable when we design a Table Model for dialogues with *wh*-questions.

The questioner A, posing a question, has goals in mind and requests B to help her to achieve these goals. For instance, the interlocutors in (26) will guess that A wants to buy the Times. She is therefore interested in places that sell the Times and that are (a) nearby, (b) open at reasonable times, (c) easy to find, (d) run by nice tradesmen etc. Speaker A requests *an exhaustive list of relevant (simple) answers to Q*. For instance, it is irrelevant for A at Konstanz to learn that the Times is sold at Frankfurt Airport. Given that there are many less costly options to get the Times, B can ignore this option. In the Extended Table Model we should refer to A's goals as well as B's attempts to answer A's needs. We should distinguish between the (literal, semantic) meaning of question Q and the information Q^+ that A in fact asks for.

This also lays the basis for A's request for a more informative answer in (5.a3): *Hm. Where else?* Speaker A does not deny the truth of B's answer but challenges B's belief that the first answer was sufficient. This supports the idea that A has in fact asked for an *exhaustive relevant answer*. The intuition can best be expressed by a tacit afterthought "...and more you need not know".

The present section implements this idea. I propose that A requests and B selects her answers according to what they believe to be RELEVANT for A at this point. RELEVANT is a property of propositions that depends on subject (relevant for who?), time (relevant when?) and context. RELEVANT is used in the informal spirit of (Grice 1957) to mean 'useful, helpful, helping A to decide which action to take'. I assume that RELEVANT is a basic notion and will not attempt to define it in terms of decision theory (van Rooij 2003). Crucial for the Extended Table Model are the logical properties of RELEVANT, as we will see.

From now on we adopt the Hamblin semantics for *wh*-questions. The meaning of Q is hence the set of all simple answers to Q. A proposition *p* is an answer to question Q iff *p* entails at least one simple answer p_i in $[[Q]]$. Let us use our standard example to explore the pragmatics of a mention-some question.

- (27) A: *Where can I buy the Times?*
 B: *In Staad.*

Assume that there are places z_1, \dots, z_{10} that potentially sell newspapers. The complete list of simple answers to A's question is thus:

$$\begin{aligned} & [[\textit{Where can I buy the Times?}]] \\ & = \{ \textit{'A can buy the Times at } z_1 \textit{'}, \\ & \quad \textit{'A can buy the Times at } z_2 \textit{'}, \\ & \quad \dots \\ & \quad \textit{'A can buy the Times at } z_{10} \textit{'}} \end{aligned}$$

Only true answers are cooperative answers. Let us assume that B believes that z_1, \dots, z_5 are places where the Times is sold. An exhaustive answer by B would hence be:

- (28) *You can buy the Times at $z_1, z_2, z_3, z_4,$ and z_5 (and nowhere else).*

Typically, this exhaustive answer is over-informative. Assume that A and B understand that A wants to *buy* the Times.⁹ B should hence select answers according to, for instance, *location* (nearby shops are better), *knowledge of A* (shops that are

⁹ Matters are different if A wants to advertise the Times on Google Maps or such.

easy to find are more helpful) or *other factors* (A wants to avoid supermarkets). In (27), B has selected just one place. A assumes that B is cooperative and offers RELEVANT answers. If B provides an answer, she signals that this answer counts as RELEVANT information; answers that B withholds can be non-RELEVANT either because they are false, or because B does not consider them helpful. Bearing this in mind, A can enrich B's answer in (27) as follows:

(29) ... B: *You can buy the Times in Staad. (This is relevant, and there is no other relevant answer to your question).*

RELEVANT takes a person A, a question Q and a context K as further parameters. I assume that the context includes information about time and world of K and can thus locate the current goals of A.¹⁰

(30) For any person A, context K, question Q and proposition p:
 RELEVANT(p, Q, A, K) presupposes that A put Q on the table in context K;
 RELEVANT(p, Q, A, K) is true iff p is a true answer to Q at the time and world of K
 and knowing p would improve A's choice of actions with the aim to achieve his/her current goals.

We assume moreover that RELEVANT is inherited from a (complex) answer p to those simple answers that are entailed by p.

(31) *Inheritance of RELEVANT*

Let Q be a question denotation of question Q, posed by A in context K.

Let p be an answer to Q.

If RELEVANT(p, Q, A, K) in the given context, then

RELEVANT(p_i, Q, A, K) for all p_i ∈ Q such that p → p_i.

“If a complex answer p to Q counts as relevant, then all simple answers to Q that are entailed by p are also relevant.”

I am aware that (31) calls out for counterexamples. We adopt it nevertheless because it guarantees “good” logical properties of the question-answer model. In the long run, it may be necessary to refine the proposal at this point and add an auxiliary predicate (e.g., *PROTO-RELEVANT*) but for the moment, my priority is to get a perspicuous working model for *wh*-questions in dialogue.

We can now define the *relevant exhaustification* of an answer S to question Q in context K, aimed at speaker A. This operation captures the idea that an answer can suggest the tacit adjunct “...and this is all you need to know”. Let p be the denotation of answer S, and Q the denotation of question Q.

(32) Let Q be a question denotation, p an answer to Q, K a given context and A be speaker in K who put Q on the table.

$R\text{-EXH}(p, Q, K, A) :=$

$p \wedge \text{RELEVANT}(p, Q, A, K)$

$\wedge \wedge \{ \neg \text{RELEVANT}(p_i, Q, A, K) \mid p_i \in Q \ \& \ \neg(p \rightarrow p_i) \}$

“p is true and relevant for A in K; no answers to the question Q are relevant for A (maybe false, maybe not helpful) unless they are entailed by p.”

¹⁰ This is not part of contexts as used by [FB] but a standard assumption in context theories.

(31) and (32) together ensure that any two relevant-exhaustive answers are mutually logically exclusive. Let Q be a question denotation, let p_1, p_2 be answers to Q which are different in the sense that they don't amount to the same simple answers to Q .

Claim: $R\text{-EXH}(p_1, Q, K, A)$ and $R\text{-EXH}(p_2, Q, K, A)$ are mutually exclusive.

Proof: p_1, p_2 answer Q , hence there are $r_i \in Q$ such that $p_1 \rightarrow r_1, p_2 \rightarrow r_2$. The answers p_1, p_2 are different, hence there is some $s \in Q$ such that $p_1 \rightarrow s$, but not $p_2 \rightarrow s$. According to inheritance, $p_1 \rightarrow \text{RELEVANT}(s, Q, A, K)$. According to non-entailment, $p_2 \rightarrow \neg \text{RELEVANT}(s, Q, A, K)$. Hence, p_1 and p_2 can not both be true.

To summarize, relevant-exhaustified answers are mutually logically exclusive. This will be very useful when we define the updates of the projected set in the Extended Table Model.

As a final remark, *logical exhaustification* is a special case of relevant exhaustification. Logical exhaustification is defined in (33) for question denotation Q and proposition p .

(33) Let Q be a question denotation, p a proposition.

$$\begin{aligned} \text{EXH}(Q, p) &:= \\ &p \wedge \exists r (r \in Q \ \& \ p \rightarrow r) \\ &\wedge \wedge \{ \neg p_i \mid p_i \in Q \ \& \ \neg(p \rightarrow p_i) \} \end{aligned}$$

“ p is true and an answer to Q , and all simple answers to the question are false, unless they are entailed by p ”¹¹

Exhaustified answers are mutually exclusive (Gronendijk and Stokhof 1984) and we have seen the advantages of mutually exclusive answers in Section 2. Logically exhaustive answers are a special case of relevant-exhaustive answers: If all true answers to Q are RELEVANT for A in K , then all true relevant-exhaustive answers to Q are also logically exhaustive. This fact echoes similar results in Ginzburg (1995: 504).

4. Questions on the Table

Let us see how these terms play out in an Extended Table Model. When A asks “*Where can I buy the Times*” in dialogue (26), both A and B understand that A aims at an update of the current CG by an exhaustive list of answers that are relevant for A 's current goals.

(34) **Putting wh-question Q on the table**

Assume that speaker A asks a question Q against context K_1 . The context K_1 is updated as follows:

- i. The question and its meaning are pushed on the table
 $T_2 := \text{push}(\langle Q, [[Q]] \rangle, T_1)$.
- ii. The question is interpreted with pragmatic enrichment. Let $Q^+ := \{ R\text{-EXH}(p, Q, A, K) \mid p \text{ is a finite conjunction of simple answers in } [[Q]] \}$. This updates the projected set.
 $PS_2 := PS_1 \cup^* Q^+$.
- iii. $DC_{A,2} = \{ A \text{ wants to know a helpful answer to } Q \}$

¹¹ $\wedge \{ \neg p_i \mid p_i \in Q \ \& \ \neg(p \rightarrow p_i) \} \approx$ the conjunction of all $\neg p_i$ where p_i is a simple answer to Q but not entailed by p .

- iv. The discourse commitments of other interlocutors and the common ground CG_1 remain unchanged.

“The discourse aims towards a state where we have a helpful (not necessarily exhaustive) answer to Q”. Note that (iii.) records that A posed the question. This will be necessary when we look at multi-agent scenarios: The player who brings up a question has special rights in the question-answer game.

Speaker B can now react. B will normally produce one or more assertions in answer to the question and then fall silent. We assume that silence can be meaningful, and that the context is updated by the *understood* assertion of B. Speaker B has actually committed to the R-exhaustification of her assertion. Thus the PS_1 and the discourse commitments of B are updated accordingly.

(35) **Asserting a pragmatically enriched Answer to Q:**

Let K_1 be a context with speakers A, B, and A has put a question Q on the table. B reacts with assertion S . For instance:

B: *You can buy the Times in Staad and at the Unishop.*

The context K_1 is updated as follows:

- i. Table $T_2 := \text{push}(\langle S, [[S]] \rangle, T_1)$
- ii. $PS_2 := PS_1 \cup \{ \text{R-EXH}([[\dots \text{ in Staad and at the Unishop }]], [[Q]], A, K) \}$
- iii. $DC_{B,2} := DC_{B,1} \cup \{ \text{R-EXH}([[\dots \text{ in Staad and at the Unishop }]], [[Q]], A, K) \}$
- iv. no other changes of K_1

(36) spells out the result of our sample question-answer sequence.

(36) ‘A can buy the Times in Staad and at the Unishop’ \wedge

$\text{RELEVANT}(\text{‘A can buy the Times in Staad and at the Unishop’}, [[Q]], A, K_1) \wedge$
 $\forall q (q \in [[Q]] \wedge \neg(\text{‘A can buy the Times in Staad and at the Unishop’} \rightarrow q) \rightarrow \neg\text{RELEVANT}(q, [[Q]], A, K_1))$

“A can buy the Times in Staad and at the Unishop, and for any other place z , it is presently irrelevant for A, given her goals, whether A could buy the Times at z .”

(36) entails that all other simple answers, for instance ‘A can buy the Times at the train station’ are considered not-RELEVANT. Thus the update of PS_1 by B’s answer will sort out all possible answers, except the one offered by B. The remaining default result of the ongoing dialogue is $CG_1 \cup \{ \text{R-EXH}([[\text{You can buy the Times in Staad and at the Unishop}]], [[Q]], A, K) \}$. B is discourse-committed to this proposition. In summary, the question-answer sequence

A: *Where can I buy the Times.*

B: *You can buy it in Staad and at the Unishop.*

results thus in a context where

- by default, A and B will learn that ‘the Times can be bought in Staad and at the Unishop, and this is all A needs to know’. (= projected set)
- B is committed to the claim that ‘the Times can be bought in Staad and at the Unishop, and this is all A needs to know’. (= DC_B).

This is the state to which A can now react. By default, A can remain silent and thereby accept the proposition in (34). The update operations of Farkas and Bruce predict that, as a consequence, A's discourse commitments DC_A will be updated by (36). This brings us to clearing the table. I propose the extended rule in (37) which will be better suited for question-answer dialogues with partial answers. (The inadequate predictions of [FB 17] are highlighted for the respective examples in Section 5.)

(37) **Clearing the table; extended version**

As soon as the discourse commitments of all interlocutors have non-empty intersection: $p \in DC_{A,n}$ and $DC_{B,n} \dots$

and moreover **the PS_n has converged to one option $PS_n = \{X\}$** , the context K_n is changed in the following ways:¹²

- i. $CG_{n+1} := CG_n \cup \{p\}$ update of common ground
- ii. $DC_{A,n+1} := DC_{A,n} \setminus \{p\}$ downdate of A's commitments
 $DC_{B,n+1} := DC_{B,n} \setminus \{p\}$ downdate of B's commitments
- iii. If an assertion $\langle S, [[S]] \rangle$ is on table T_n and CG_{n+1} entails $[[S]]$, then $\langle S, [[S]] \rangle$ is removed from the table.
- iv. If a question $\langle Q, [[Q]] \rangle$ is on the table T_n and CG_{n+1} entails $q \in [[Q]]$, then $\langle Q, [[Q]] \rangle$ is removed from the table.

According to (37), questions are only cleared from the table when the PS records that the conversation has converged to one option. In the simple examples in this paper, $PS = \{X\}$ where X is equivalent to CG_{n+1} : For all p , if $CG \models p$ then $X \rightarrow p$ and vice versa.

In our newspaper example, the new rule has the effect that B's assertion $\langle S, [[S]] \rangle$ as well as A's original question $\langle Q, [[Q]] \rangle$ are removed from the table. To check the latter, remember that in a Hamblin semantics for questions, all simple answers are elements of $[[Q]]$. Given that the weak exhaustification of B's assertion entails one or more simple answers, rule [FB17.iv] takes action. In sum, we predict that the common ground is updated with the information that the Times is available in Staad and the university shop. The projected set is a singleton. The dialogue is in a stable state.

Let us turn to denials. A can also refute B's answer.

- (38) A: *Where can I buy the Times?*
 B: *In Staad.*
 A: *No, I checked and they don't sell it.*

Like in the earlier case, B's response generates a context K_n where '*...in Staad*' is the default outcome. A's response commits her to the negation of B's belief.

(39) **A denies B's answer**

The table T_1 contains a question $\langle Q, [[Q]] \rangle$ raised by A, and assertion $\langle S, [[S]] \rangle$ by B. A utters something to the end that negates B's assertion. E.g., A: *No.*

- i. $T_2 := \text{push}(\langle \text{No}, \neg[[\dots \text{in Staad}]] \rangle, T_1)$

¹² Note: The present definition can not deal with sequences of questions. A fully recursive rule to clear the table should spell out: "All options in PS_n entail the same answer to Q."

- ii. $DC_{A,2} := DC_{A,1} \cup \{ \neg[[A \text{ can buy the Times in Staad }]] \}$
 $DC_{B,2} = \{ \dots, [[A \text{ can buy the Times in Staad }]] \}$
- iii. $PS_2 = PS_1$
- iv. $CG_2 = CG_1$

In terms of Farkas and Bruce, the discourse is in a crisis and the simplest outcome is one where A and B agree to disagree. The conflicting assertions are removed from the table. The diverging discourse commitments are retained. The common ground is not updated. As a consequence, the new **Clearing** rule does not apply and the question remains on the table. This is an adequate prediction.

B might provide a complex answer and A denies only part of it.

- (40) A: *Where can I buy the Times?*
 B: *In Staad and at the Unishop.*
 A: *Well, I checked at the Unishop and they don't sell it.*

In this case, A and B still agree on the other part of B's answer. Their DC and the common ground is updated accordingly. As soon as *one* answer to Q is part of the common ground, the question is removed from the table, due to [FB 17].

In summary, the new rule (34) puts a *wh*-question on the table, the new rule (35) allows us to interpret an answer as *relevant-exhaustive* answer and the new rule (37) clears *wh*-questions from the table. The operation *denial* was provided by Farkas and Bruce's basic model. The next subsection investigates a new kind of denial that goes beyond the basic model.

4.2 Questioner A asks for more information

The dialogue in (41) illustrates A's option to ask for more information. For the sake of concreteness, let us assume that the exchange starts against the empty table and common ground CG_1 .

- (41) A: *Where can I buy the Times?*
 B: *You can buy the Times in Staad.*
 A: *Hmm. Any other options?* ('Where else can I buy the Times?')

A's reply does not challenge the truth of B's simple answer. Instead, speaker A challenges the content of exhaustification, specifically that 'all other simple answers to Q are not RELEVANT for A'. A requests B to re-think her notion of RELEVANT, and wants to get true answers that have been sorted out by B. Speaker A can give hints as to which other answers might matter: *I travel to Frankfurt quite often*, or *I am regularly downtown*.

There are various kinds of utterances *R* that entail $\neg(\text{R-EXH}(\llbracket S \rrbracket, Q, K, A))$ (= *It is false that* "S is true, and this is all that A needs to know in answer to Q in K"). *R* could be an assertion: *This is not enough*, or a question: *Hm. Any other answers?/Who else Q?, Where else Q?*¹³ Let us assume that the semantic object behind these reactions is a *wh-else* question. *Wh-else* questions refer to a given discourse background where a question has been partially answered. Let us assume that a *wh-else-Q* is anaphoric to previous discourse. It denotes the set of simple answers to Q such that the current common ground entails neither the answer nor its negation.

¹³ According to (Ginzburg 1995), A might likewise challenge the level of detail or other forms of inadequacy (see below); but for the moment I focus on the simplest possible cases.

- (42) $[[\textit{wh-else} Q]]$, interpreted in context K_n :
 $[[\textit{wh-else} Q]]$:= $[[Q]]$ \ $\{ p \mid p \in [[Q]]$ \wedge $CG_n \models p$ or $CG_n \models \neg p \}$
 “The meaning of a *wh-else* question Q is the same as the meaning of the original question Q , except answers that are already decided by the common ground (including those that have just been given).”

A wants to keep this question on the table and B is requested to provide more answers: *wh-else* Q is a subquestion of Q . This explains why A’s discourse move challenges B’s commitment that the first answer was sufficient. I assume that A’s request changes the current context K_1 by a combination of updates and downdates. In particular the emerging projected set PS_2 has to code that (a) an answer has been accepted and (b) a *new* question has been put on the table at the same time. This requires an integrated update to get old moves off the table as well as bring new moves on the interlocutor’s agenda. The rule in (43) integrates these effects.

(43) **Asking back**

Presupposed: K_1 records that A has put a question Q on the table and B has provided answer S . A reacts to the assertion S .¹⁴

- i. $DC_{A,2} := DC_{A,1} \cup \{ [[S]]$ \wedge \neg (R-EXH($[[S]]$, Q , K_1 , A)) $\}$
 A is committed to a partial answer to Q , and the belief that this is an insufficient answer to Q .
- ii. $CG_2 := CG_1 \cup \{ [[S]]$ $\}$
 CG is updated accordingly: A and B share DC that entail $[[S]]$
- iii. $T_{1.5} :=$; pop($\langle Q, [[Q]] \rangle$, pop($\langle S, [[S]]$ \rangle , T_1))
 both question Q and assertion S are downdated from the table
- iv. $T_2 :=$ push($\langle \textit{wh-else} Q, [[\textit{wh-else} Q]]$ \rangle , $T_{1.5}$)
 A’s new question *wh-else* Q is put on the table
- v. $PS_2 :=$ $\{ CG_2 \cup * \{ R-EXH(a, [[\textit{wh-else} Q]]$, A , K) $\mid a$ answers *wh-else* Q $\}$
 A expects an answer to the subquestion *wh-else* Q .

At this point A and B have to negotiate conflicting discourse commitments: While A thinks that the given answer was insufficient, B believes that it was an exhaustive relevant answer for the given purpose. If B believes that there are no other true simple answers then B should say so. In this case, the question is removed from the table without being considered further. We do not have a formal rule as yet to do this, but Section 5 introduces *Exhaustification* (51) that has this effect.

If B thinks that there are other true answers, B is requested to revise her beliefs about the extension of $\lambda q. \text{RELEVANT}(q, [[Q]]$, A , K_1) and produce more answers. The next moves by A and B can be analysed by the existing set of update rules.

Before moving on, it may be valuable to compare the present account to the more general view developed in Ginzburg (1995). Ginzburg uses the notion of *resolving information* for a given question. Ginzburg has in mind more ways in which answers can be insufficient. For instance, he discusses the case where A asks “*Who will attend the lecture?*” and is interested in the kind of people (astrophysicists, semanticists, soccer players) rather than the identity of people (Peter Brown, Anna Smith, Barry Parson...). Ginzburg suggests that GOAL, a question-like entity, specifies

¹⁴ The operation requires two updates of the table: Assertion and first question are removed and a new question is on the table. The intermediate structure carries index 1.5. This should not be misunderstood to entail that the account uses a continuum of context structures.

information that would resolve Q for A. The propositions in A's GOAL need not be part of the semantic meaning of Q. This strategy allows Ginzburg to model more varied mismatches between *expected* answers and *given* answers, and he can successfully predict that A can ask for better information without wanting "more" information.

We could integrate the benefits of his analysis if we give up the idea of *relevant exhaustification* as the limiting pragmatic force in question interpretation. We could instead claim that A, while uttering Q, *in fact* asks something like Ginzburg's GOAL and that B has to provide information reflected in GOAL rather than answers to Q. While the idea is fascinating, I hesitate to propose a system that allows us to freely exchange question meanings by "intended questions". Once we get a better understanding of how Ginzburg's GOAL set of information can be derived from the original question Q in context, this could be an attractive further version of the Extended Table Model. For the moment, I stick with a conservative model. Consequently, *Wh-else* questions are the standard form of back-questioning for speakers who did not get satisfactory answers.

4.3 Exhaustive answers: The coffee example

This section investigates how exhaustive questions play out in the Extended Table Model. Reconsider the coffee case, repeated in (44).

- (44) A: *Who wants coffee?* (referring to Ann, Bertha and Chris)
 B: *Ann and Chris want coffee.*

Let us assume a situation where A wants to buy coffee for all those who want coffee. Both A and B understand that A's goals are best achieved if s/he has exhaustive information. In other words: All true simple answers to Q are relevant for A's given purpose. We use the rule for **Putting wh-question Q on the table**, repeated in (45).

- (45) Putting wh-question Q on the table
 Assume a context K_1 with speakers A, B, \dots common ground CG_1 , projected set PS_1 and table T_1 . A raises a question, e.g.:
 A: *Who wants coffee?* (= Q)
 Changes of Context K_1 :
 Table $T_2 := \text{push}(\langle Q, [[Q]] \rangle, T_1)$
 $PS_2 := PS_1 \cup \{ R\text{-EXH}(p, Q, K, A) \mid p \text{ answers } [[Q]] \}$
 $DC_{A,2} := DC_{A,1} \cup \{ 'A \text{ wants to know the answer to } Q' \}$
 no other changes of K_1

In this case, *all* simple true answers are relevant for A. Relevant-exhaustified answers are therefore logically-exhaustive answers that spell out for each of Ann, Bertha and Chris whether they want coffee.

Assume next that B offers an assertion in return: *Ann and Chris want coffee*. B's answer and subsequent silence are interpreted as exhaustive: 'Ann and Chris want coffee, and there is no other proposition of the form $x \text{ wants coffee}$ that is true'. B is committed to this content, and the projected set is updated by rule (35).

- (46) B: *Ann and Chris want coffee.* (= S)
 Change of context K_1 :
 Table $T_2 := \text{push}(\langle S, [[S]] \rangle, T_1)$

$$\begin{aligned} \text{PS}_2 &:= \text{PS}_1 \cup * \{ \text{R-EXH}([\text{Ann and Chris ...}], \mathbf{Q}, \mathbf{K}, \mathbf{A}) \} \\ \text{DC}_{B,2} &:= \text{DC}_{B,1} \cup \{ \text{R-EXH}([\text{Ann and Chris ...}], \mathbf{Q}, \mathbf{K}, \mathbf{A}) \} \\ &\text{no other changes of } \mathbf{K}_1 \end{aligned}$$

The resulting context has B's assertion on the table. PS and DC_B record that B is committed to the stronger exhausted proposition: "Ann and Chris, but not Bertha, want coffee". The default result of the dialogue at this point is $\text{CG}_1 \cup \{ \text{'Ann and Chris, but not Bertha, want coffee'} \}$. All other options are logically incompatible with B's exhausted answer and are hence dismissed after B's reply. This is an appropriate prediction.

The possible reactions of A are accepting and denial as before.

- (47) A: *Who wants coffee?* (referring to Ann, Bertha and Chris)
 B: *Ann and Chris want coffee.*
 a. A: *Ok.*
 b. A: *Huh? Ann told me that she does not drink coffee.*

The subsequent stages of the table can be computed exactly as before and the details are left to the reader.

4.4 A brief look at negated questions

Users of [FB] will have noticed that our objects on the table look simpler than those in Farkas & Bruce (2010). They use structured meanings to record the presence of negation in questions and assertions, aiming at an analysis of confirming and reversing responses to polar questions. Our account does not record the presence/absence of negation. The present section takes a brief look at *wh*-questions with a negated root clause to confirm that question polarity does not influence *wh*-questions in the same manner as polar questions. This will justify our decision in favour of simple semantic objects.

Consider the *wh*-questions in (48) and (49).

- (48) *Which trousers don't you wear any longer?*
Which movies have not started yet?
Who doesn't want beer?
 (49) *Who has not, at times, wanted to kill his spouse?*
Who would not accept this offer?

Under normal circumstances, the questions in (48) are serious questions and require an answer; in fact a negative answer. They suggest a context where the negative cases are more helpful or rarer than the positive cases. The speaker has reason to elicit simple answers of the form "*I no longer wear ...*", "*Movies A, B and C have not started yet*", and "*X, Y and Z do not want beer.*" It is easy to think of situations where these propositions are more helpful than a list of positive sentences. If the speaker wants to decide which movie she should buy tickets for, it does not help her to learn that 20 movies have started already — she needs to know the 3 good movies that have not. If twenty thirsty Bavarians enter a pub, it may be easier to find out who doesn't want beer than to count those who do. The speaker who asks one of the questions in (48) has decided that, under the given circumstances, the list of negative instances — simple answers to negated questions — are more helpful than the list of positive

instances — simple answers to a corresponding positive question. It would be wrong to assume that negative sentences are less relevant or rhetorically marked *per se*.

Some negated questions, however, do convey a rhetorical intention. The questions in (49) strongly suggest a bias for negative answers: *Nobody*. We could view the bias as an extreme form of the pragmatic restrictions to negative questions in (48): these are limited to contexts where negative cases are few and easy to list; biased questions are limited to contexts where negative cases are nil. However, not every negated *wh*-question is a biased question, and thus biased questions should be left for further research. In essence, the first version of an Extended Table Model does not need to distinguish between negated and non-negated constituent questions. This further level of detail can be added to the present analysis without changing the gist of the proposal.

5. Partial answers

So far, we restricted attention to dialogues where the answerer B gave sign that the answer was intended as relevant-exhaustive. This is not always the case, though. Speakers can signal that their answer is partial. In particular, expressions of information structure such as strategies or left-dislocation can indicate partial answers (see 1.3). If we want to link the Table Theory to theories of Question under Discussion theory, the Table Theory has to account for partial answers. The present section investigates these. It turns out that we did a good job: Sequences of partial answers can successfully be treated in the account. What is still missing, though, is a rule that allows interlocutors to agree that the current knowledge state suffices to resolve the question.

5.1 Series of partial answers

Consider discourse (50) between persons A – E. (E remains silent.)

- (50) A: *Who can feed the cat next week?*
 B: *I can't. (I am on vacation.)*
 C: *M neither. (I am allergic to cats.)*
 D: *I can do.*

Let us assume that A needs at most two words; hence helpful exhaustive answers should not list more than two persons. Assume moreover that *all* answers in discourse are given with the understanding that the answer is considered relevant by the speaker (Gricean cooperativity assumption). An analysis of (50) according to the rules in Section 4 proceeds as follows. In the first move, A puts the QuD on the table. The R-exhaustified content of the question updates the projected set PS.

$$PS_2 := PS_1 \cup * \{ \text{R-EXH}(p, \text{QuD}, K_1, A) \mid p \text{ is an answer to QuD} \}$$

Starting from stable context K_1 , and assuming interlocutors A, ..., E we arrive at K_2 :

A	Table	B	C	D	E
DC _{A,2} Want Q	< <i>who...?</i> , [[<i>who...?</i>]]>	DC _{B,2}	DC _{C,2}	DC _{D,2}	DC _{E,2}

$CG_2 = CG_1$	$PS_2 = \textit{see below}$
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I give the full computation of the projected set(s) in order to demonstrate the stepwise reduction of options after each of the responses. The first PS includes all options raised by A's question.

$$PS_2 = PS_1 \cup *$$

{ 'B can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'C can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'D can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'E can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'B and C can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'B and D can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'B and E can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'C and D can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'D and E can feed the cat this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'C and E can feed the cat this is relevant; all other $p \in [[Q]]$: p is not relevant' }

The assertion of B reduces these options although it does not helpfully answer A's question. We reach context K_3 .

A	Table	B	C	D	E
DC _{A,3} Want Q	<who can feed the cat?, [[who...?]]> <I can't ..., 'B can not feed the cat'>	DC _{B,3} p_B can not feed the cat	DC _{C,3}	DC _{D,3}	DC _{E,3}
CG ₃ = CG ₁		PS ₃ = <i>see below</i>			

$$PS_3 = (PS_1 \cup *$$

{ 'C can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'D can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'E can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'C and D can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'D and E can feed the cat this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'C and E can feed the cat this is relevant; all other $p \in [[Q]]$: p is not relevant' })
 $\cup * \{ p_B \text{ can not feed the cat} \wedge \text{RELEVANT}(p_B, Q, A, K) \}$

Options where B does the feeding are no longer consistent with the information state that the discourse moves toward. They have been removed.

I leave it to the reader to compute A, C, D and E's silent consent and the common ground update. We will assume that the CG update has been included and B's assertion is removed from the table. The next move is C's assertion which brings us to context K_4 .

K₄

A	Table	B	C	D	E
DC _{A,4} Want Q	<who can feed the cat?, [[who...?]]> <I can't ..., 'C can not feed the cat'>	DC _{B,4}	DC _{C,4} <i>p_C</i> can not feed the cat	DC _{D,4}	DC _{E,4}
CG ₄ = CG ₁ ∪ { <i>p_B</i> can not feed the cat ∧ RELEVANT(<i>p_B</i> , Q, A, K) }		PS ₄ = <i>see below</i>			

PS₄ = (PS₁ ∪ *
 { 'D can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'E can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'D and E can feed the cat this is relevant; all other $p \in [[Q]]$: p is not relevant' })
 ∪ * { *p_B* can not feed the cat ∧ RELEVANT(*p_B*, Q, A, K) }
 ∪ * { *p_C* can not feed the cat ∧ RELEVANT(*p_C*, Q, A, K) }

All options where C does any feeding have been removed. As before, silent consent, CG update and removal of '*C can't feed the cat*' take place.

The next step is the assertion by speaker D, by which we reach context K₅.

A	Table	B	C	D	E
DC _{A,5} Want Q	<who can feed the cat?, [[who...?]]> <I can feed ..., 'D can feed the cat'>	DC _{B,5}	DC _{C,5} <i>p_C</i> can not feed the cat	DC _{D,5}	DC _{E,5}
CG ₅ = CG ₁ ∪ { <i>p_B</i> can not feed the cat ∧ RELEVANT(<i>p_B</i> , Q, A, K) } ∪ { <i>p_C</i> can not feed the cat ∧ RELEVANT(<i>p_C</i> , Q, A, K) }		PS ₅ = <i>see below</i>			

PS₅ = (PS₁ ∪ *
 { 'D can feed the cat, this is relevant; all other $p \in [[Q]]$: p is not relevant',
 'D and E can feed the cat this is relevant; all other $p \in [[Q]]$: p is not relevant' })
 ∪ * { *p_B* can not feed the cat ∧ RELEVANT(*p_B*, Q, A, K),
p_C can not feed the cat ∧ RELEVANT(*p_C*, Q, A, K),
p_D can feed the cat ∧ RELEVANT(*p_D*, Q, A, K) }

Speaker A has received one simple answer to Q. The 'E can feed'-answer has been removed because it entails that *p_D* is not relevant. Formally, speaker A's question is still unresolved. The projected set contains two options whereas our clearing rule requires a non-branching projected set.¹⁵ After a longer exchange like this the

¹⁵ Farkas & Bruce's [FB 17] would remove the question from the table after D's answer, leaving us with a branching projected set. This is inadequate even if A accepts the current information state as resolving: The PS aims at two different possible CG.

interlocutors look at speaker A, the one who raised the question, for feedback. A can show one of two reactions.



A can look unhappy. PS is not yet a singleton, so the question will not be removed. The discourse continues.



A could also look satisfied: :) — a new type of silent consent in discourse. No further requests are needed, the current information is accepted as satisfactory (Ginzburg 1995: resolves the question).

In the case of unhappy A, the discourse continues and with one further assertion by E, the PS is reduced to one option and the question will be resolved. —The happy smile of A, however, constitutes another discourse move where silence is meaningful.

(51) **Exhaustify current knowledge**

Precondition: K_n is a context with a question Q on the table. PS is not a singleton. Let \mathcal{p} be the proposition such that \mathcal{p} answers Q , $CG \models \mathcal{p}$ and for all p : if p answers Q and $CG \models p$ then $\mathcal{p} \rightarrow p$. (\mathcal{p} is the strongest known answer to Q .) Assume that speaker A raised the question and gives us the satisfied smile. In this case:

1. Increase $CG_{n+1} := CG_n \cup \{ R\text{-EXH}(\mathcal{p}, Q, A, K_n) \}$
2. Update $PS_{n+1} := PS_n \cup^* \{ R\text{-EXH}(\mathcal{p}, Q, A, K_n) \}$

In a single-question discourse, exhaustification cuts down the projected set. $PS = \{X\}$ and X is equivalent to CG . Hence, the conditions to remove Q from the table are met. The discourse reaches a stable state.

In summary, the present section demonstrates how partial answers lead to a stepwise reduction of the projected set. The question under debate can be removed from the table when no further simple answers are left to be checked. Alternatively, the questioner A can indicate that the current content of the common ground is sufficient for her purpose. In this case, the common ground is updated by the R-EXH exhaustification of the strongest known answer. This excludes all other remaining options in PS and clearing (rule (37)) can take place.

5.2 Markers for non-exhaustive answers

The Table Model of Farkas & Bruce allows us to explore default and non-default moves in dialogue. Their basic model assumes that silent consent is the default reaction to assertion. The present extension identified yet another case of meaningful silence. Silence following an answer to *wh*-question Q triggers R-EXH exhaustification of the answer. It is thus to be expected that speakers explicitly signal if they want to have their answer interpreted as non-exhaustive. While real-world dialogues leave some leeway for interpretation, there seems at least a trend in the expected direction. Indeed there is a range of linguistic items that serve to signal partial answers.

5.2.1 Signalling a strategy

(Büring 2003) discusses examples where prosody indicates that the speaker has a specific range of questions at the back of her mind. Contrastive topic and focus are indicated by A- and B-accent in English, by rising and falling accents in German ('Hutkontur'). I add the pragmatic glossing without reference to particular accents.

- (52) A: *Who can feed the cat next week?*
 B: [I]_{CT} *am* [*on vacation*]_F.

B's response translates into a set of subquestions *Where is B, Where is C, Where is D, Where is E?* which are part of the superquestion *Who is where?* B's answer is not directly helpful for A's purpose, but B is indirectly helpful by bringing up a more general question the answer to which might be useful to answer A's original question. In formal terms, B's assertion does not settle A's question. It does not settle B's superquestion either (*Who is where?*). It exhaustively answers the subquestion *Where is B?* A treatment of implicit questions is still missing in the Table Model. It remains to be investigated whether B's question *Who is where?* turns into a compulsory part of the table. Intuitively, it seems up to A whether the question *Who is where?* will be pursued exhaustively, and which signals trigger removal of the question from the table. A detailed treatment of implicit questions remains to be developed.

5.2.2 Other indicators

Answers to a question can be marked as partial by tags like *for instance* or by rising intonation.

- (53) A: *Where can I find Ms Smith's phone number?*
 B: *Well, in the Frankfurt phone book for instance?*

These signals should be interpreted so as to block the relevant-exhaustified interpretation of B's answer. B does not commit herself to the claim "... and this is all you need to know." Instead, B leaves it to A to give the satisfied smile and trigger exhaustion, or to ask back for further simple answers. B actively avoids the meta-crisis and leaves it to A what is considered helpful information.

5.2.3 The discourse pragmatics of 'not only'

The use of *not only* serves to block exhaustification. Here is our initial example.

- (54) B: *Ms. Smith is not only a superb mathematician.*

The use of focus-sensitive 'only' requires alternatives to 'superb mathematician' to be salient in the ongoing discourse. According to standard assumptions, we can view these alternatives as an instalment of a question under discussion QuD (e.g. Kadmon, 2001). The utterance of B refers to the QuD "*Which laudable properties does Ms Smith have?*". The question is either in the air already or is accommodated after B's utterance. (54) presupposes the proposition 'Ms Smith is a superb mathematician'. Hence, a simple answer to the QuD is already part of the common ground (or should be accommodated). However, B asserts that this is not the only true answer, and that this fact is relevant. Therefore B blocks **exhaustification**. As a consequence, the dialogue is in a state where the projected set PS_n records many further simple answers to the QuD as possible outcomes of the ongoing debate. The dialogue is not in a state that allows **Clearing** (37). The context does not reach a stable state. The analysis hence predicts that the QuD has to be pursued further—be it by B or other knowledgeable speakers.

This preliminary survey shows that speakers can change the table in sophisticated ways, leaving detailed instructions as to how the ongoing discourse should develop.

With the present Extended Table Model, an in-depth investigation of patterns and a deeper understanding of how information structure drives discourse is in reach.

6. Summary

The present paper investigates *wh*-questions as moves on the table. Section 1 surveys possible question-answer dialogues. The speaker can request an exhaustive answer or a mention-some answer. If all answers to a question are mutually exclusive, the two cases coincide. Once an answer has been produced, the questioner has different options to react: S/he can accept the answer, challenge the answer, and — in the case of mention-some answers — ask back for more information. Partial answers create an obligation for interlocutors to continue the exchange.

Section 2 recapitulates the core rules of (Farkas & Bruce 2010) and discussed plausible ways to extend this system for constituent questions. The formal details of the extension depend on the question semantics that is put to use: (Groendijk/Stokhof 1984) model questions as sets of *exhaustive* answers whereas (Hamblin 1974) proposes to analyse questions as sets of *simple* answers. It turned out that neither choice leads to a working Table Model for *wh*-questions.

Section 3 proposes that *exhaustive relevant* answers to questions should play a central role in the Table Model. Exhaustive relevant answers are answers, pragmatically enriched by “...and this is all you need to know for now.” Section 3 formalizes this idea. The analysis is based on Hamblin’s semantics for questions. Section 3.1 introduces the relation $\text{RELEVANT}(p, Q, A, K)$ between agent A, context K, question Q and answer *p*. This allows us to define relevant-exhaustive answers to Q. These are answers *p* to Q such that all further simple answers *r* that are not entailed by *p* are not relevant for A in the given context K. Assuming that RELEVANT is inherited from complex to simple answers, it can be shown that any two relevant-exhaustive answers to Q are mutually exclusive. Relevant-exhaustive answers hence combine the logical elegance of exhaustive answers with the plausibility of partial answers. Logically exhaustive answers are the limit case of relevant-exhaustive answers when all simple answers to Q are relevant for the questioner.

Section 4 puts these definitions to use in an extended table model. Section 4.1 defines the effects of **putting a question on the table** and of relevant-exhaustifying an **assertion** in reply to a question. The **Clearing** rule is also adjusted to *wh*-questions. Section 4.2 treats the case where the questioner asks back for more information. Section 4.3 demonstrates the adequacy of the proposed rules in question-answer dialogues where the questioner asks for an exhaustive answer (the *coffee* example). Section 4.4, finally, takes a look at polarity in *wh*-questions and concludes that polarity does not automatically lead to biased constituent questions. This allows us to keep the representation of utterances on the table overall simpler than in Farkas and Bruce.

Section 5 addresses partial answers. The operation R-EXH does not apply and thus, partial answers do not cut down the projected set to one option. On basis of the operations in Section 4, we predict that the question can only be removed from the table if all simple answers have been addressed. In order to bring the model closer to real life, we added an exhaustification rule that can shortcut. If speakers agree that the current CG resolves the question, all further simple answers can be declared irrelevant and the exchange can be brought to a stable state.

The end of Section 5 undertakes a first exploration of linguistic signals for partial answers. Specifically, discourse moves that have been investigated as QuD related moves, e.g. opening an implicit QuD or a strategy, are often based on partial answers. The tools provided by the present account are hence absolutely necessary to pursue Farkas and Bruce's larger research agenda: The investigation of QuD related moves as moves on the Table. This promises a deeper understanding of the communicative effects of information structure.

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