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2 Modelling Questions in Commitment Spaces

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Abstract
The paper outlines the analysis of certain question types in the Commitment Space framework, as presented in Krifka (2015). The two basic ideas are: Assertions and most questions involve commitments of speaker and addressee to the truth of a proposition, and questions consist in restricting the continuation of the conversation to answers to the question. The main focus is on breadth, not depth and the detailed comparison with alternative approaches, and on semantic modelling, not on the syntactic and prosodic realizations. Topics are polar questions and their bias, alternative questions, constituent questions, high negation in questions, declarative questions, root vs. embedded questions, and deliberative questions.

2.1 Common Grounds and Context Sets

Common Ground (CG) is "a body of information that is available, or presumed to be available, as a resource of communication" (Stalnaker 1978); communication is seen as a sequential update of the CG. I will provide here a CG model for assertions and questions. As a model, it will not capture all aspects of reality. Important properties of the CG, like anaphoric relations, will not be covered. Also, this short paper cannot go into a detailed comparison of recent alternative accounts that have similar goals, such as Groenendijk (1999), Farkas & Bruce (2010), Farkas & Roelofsen (2017), and Ciardelli et al. (2018).

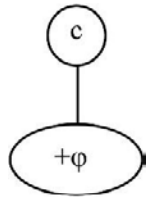
1 I gratefully acknowledge support through the ERC Advanced Grant 787929 SPAGAD – Speech Acts in Grammar and Discourse. Ideas of this paper have been presented at several workshops and conferences, and I thank the many colleagues that helped to refine them. It goes beyond the presentation in the workshop "Asking and Answering" in discussing the issue of embedded questions.

The classical way to model CGs is by propositions or sets of possible worlds ("context sets"), as in Stalnaker (1978). Other models that have been proposed are interpreted pieces of a formal language (Kamp 1981), pairs of assignment functions and propositions (Heim 1983), or sets of propositions (Krifka 2015). Here I will assume the simple classical view, and model CGs as sets of possible worlds.

Let c be a context set, a set of possible worlds {w, w′, …}. Let φ_t be the proposition 'Max arrived' interpreted at t. An update of c at time t_0 can be rendered as follows:

(1) $c +_{t_0} \varphi = \{w \in c \mid \varphi_{t_0}(w)\}$

$= \{w \in c \mid \exists t\, [t < t_0[\text{arrive}_{w,t}(m)]]\} = c'$



The picture on the right margin indicates a change of a context set c at time t_0 to the context set c′ that is generated by updating c with φ. Aspects like the temporal component are not indicated in these representations.

2.2 Commitment States

But how does a speaker bring it about that a proposition becomes established as part of the Common Ground? Lauer (2013) argued that we have to distinguish between different steps in this process. In Krifka (2015) I followed Charles S. Peirce in assuming that a crucial step is the expression of a commitment by the speaker to the truth of the proposition (cf. also Gunlogson 2008, Shapiro 2020). In Krifka (2021) I proposed that there are distinct layers in the syntactic representation of assertions that can house various epistemic, evidential and commitment-related operators. As these meaning aspects are essential for the understanding of questions, I will introduce them here as well.

At the core is the proposition itself that should be communicated, syntactically a TP ("tense phrase"); it is interpreted with respect to parameters s, a, t representing speaker, addressee, time and other aspects of the context of utterance:

(2) $[\![[_{TP}\ \textit{Max arrived}]]\!]^{s,a,t} = \lambda w \exists t'\ [t' < t \wedge \text{arrive}_{w,t'}(m)] = \varphi_t$, for short

The next layer is the judgement phrase JP with head J- that introduces a judge argument j; I follow here X-bar syntax. (3) is the compositional interpretation rule, (4) an example.

(3) $[\![[_{JP}\ [_{J'}\ [_{J^o}\ \text{J-}]\ [_{TP}\ \ldots]]]]\!]^{s,a,t} = [\![\text{J-}]\!]^{s,a,t}([\![[_{TP}\ \ldots]]\!]) = \lambda j\ [\![[_{TP}\ \ldots]]\!]^{s,a,t}$

(4) $[\![[_{JP}\ [_{J'}\ [_{J^o}\ \text{J-}]\ [_{TP}\ \textit{Max arrived}]]]]\!]^{s,a,t} = \lambda j \lambda w \exists t'\ [t < t_o \wedge \text{arrive}_{w,t'}(m)] = \lambda j\ \varphi_t$

Evidential and epistemic operators like *reportedly* and *probably* are realized within the JP. For example, *probably* expresses that j assigns a probability substantially greater than 0.5 to the proposition. In (5) $P_{j,w,t}(\varphi_t)$ stands for the probability j assigns to φ_t in w at t.

(5) $[\![[_{JP}\ [_{J'}\ \textit{probably}[_{J'}\ [_{J^o}\ \text{J-}]\ [_{TP}\ \textit{Max arrived}]]]]]\!]^{s,a,t} >= \lambda j \lambda w\ [P_{j,w,t}(\varphi_t) > 0.5]$

The next layer is the Commitment Phrase ComP with head[2] $\vdash$ that states that the judge j is publicly committed to the truth of the JP proposition at w and t.

(6) $[\![[_{ComP}\ [_{C'}\ [_{C^o}\ \vdash]\ [_{JP}\ \ldots]]]]\!]^{s,a,t} = [\![\vdash]\!]^{s,a,j}([\![[_{JP}\ \ldots]]\!]^{s,a,t}) = \lambda j \lambda w\ [j \vdash_{w,t} [\![[_{JP}\ \ldots]]\!]^{s,a,j}(j)]$

(7) $[\![[_{ComP}\ [_{Com'}\ [_{Com^o}\ \vdash]\ [_{JP}\ [_{J'}\ \textit{probably}[_{J'}\ [_{J^o}\ \text{J-}]\ [_{TP}\ \textit{Max arrived}]]]]]]]\!]^{s,a,t}$
$= \lambda j \lambda w\ [j \vdash_{w,t} \lambda w\ [P_{j,w,t}(\varphi_t) > 0.5]]$

Commitments can be modified by operators like *truly* and *seriously* that specify the nature of the commitment. There is no established theory of commitment specifiers.[3] For illustration, *seriously* indicates that the commitment is serious, which implies that social sanctions would be more severe if it was done in joke or without sufficient evidence.

2 The turnstile symbol $\vdash$ goes back to Frege (1879), the judgement stroke, which distinguishes between a proposition and the judgement that this proposition is true. Cf. Cordes (2014).

3 Vanderveken (1990) does not propose a semantic representation to his notion of "strength".

(8) $[\![[_{\text{ComP}}\ [_{\text{ComP}'}\ \textit{seriously}[_{\text{Com}'}\ [_{\text{Com}^0}\ \vdash]\ [_{\text{JP}}\ [_{\text{J}'}\ \textit{probably}[_{\text{J}'}\ [_{\text{J}^0}\ \text{J-}]\ [_{\text{TP}}\ \textit{Max arrived}]]]]]]]]]\!]^{s,a,t}$

$= \lambda j \lambda w\ [j\ \text{serious}(\vdash)_{w,t} \lambda w\ [P_{j,w,t}(\varphi_t) > 0.5]]$

In case there is no judgement or commitment modifier, interpretation is as in (9).

(9) $[\![[_{\text{ComP}}\ [_{\text{C}'}\ [_{\text{C}^0}\ \vdash]\ [_{\text{JP}}\ [_{\text{J}'}\ [_{\text{J}^0}\ \text{J-}]\ [_{\text{TP}}\ \textit{Max arrived}]]]]]]\!]^{s,a,t} = \lambda j \lambda w\ [j \vdash_{w,t} \varphi_t]$

In a final step, this is turned into a function that takes a context set, speaker, addressee and time and delivers an output context set. I call the syntactic layer ActPhrase, ActP, with • as the head of assertive ActPs. This operator identifies the judge j with the speaker s.

(10) $[\![[_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^0}\ \bullet\ ]\ [_{\text{ComP}} \ldots]]]]\!]^{s,a,t} = [\![\bullet]\!]^{s,a,t}([\![[_{\text{ComP}} \ldots]]\!]^{s,a,t})$

$= \lambda c\ \{\ w \in c\ |\ [\![[_{\text{ComP}} \ldots]]\!]^{s,a,t}(s)(w)\}$

(11) $[\![[_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^0}\ \bullet\ ]\ [_{\text{ComP}}\ [_{\text{C}'}\ [_{\text{C}^0}\ \vdash]\ [_{\text{JP}}\ [_{\text{J}'}\ [_{\text{J}^0}\ \text{J-}]\ [_{\text{TP}}\ \textit{Max arrived}]]]]]]]]\!]^{s,a,t}$

$= \lambda c\ \{w \in c\ |\ [s \vdash_{w,t} \varphi_t]\}$

The update of an input context set c by speaker s to addressee a at time t is interpreted by rule (12), exemplified in (13).[4] The output context contains the proposition that s_1 is committed to the proposition that Max arrived.

(12) $c +_{s,a,t} [_{\text{ActP}} \ldots] = [\![[_{\text{ActP}} \ldots]]\!]^{s,a,t}(c)$

(13) $c_0 +_{s_1,s_2,t_0} [_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^0}\ \bullet\ ]\ [_{\text{ComP}}\ [_{\text{C}'}\ [_{\text{C}^0}\ \vdash]\ [_{\text{JP}}\ [_{\text{J}'}\ [_{\text{J}^0}\ \text{J-}]\ [_{\text{TP}}\ \textit{Max arrived}]]]]]]]^{s_1,s_2,t_0}$

$= \{w \in c_0\ |\ s_1 \vdash_{w,t_0} \varphi_{t_0}\}$

In addition to the construction of an assertive update via an ActP, the core proposition of the TP within the ActP remains accessible as well. This can

4 This is a simplification. Update by an assertion is not an informative update about how the world is like (Stalnaker), but rather a performative update that changes the world, as proposed by Szabolcsi (1982). Krifka (2014) proposes an operation that changes a possible world minimally so that a proposition becomes true; using "+" for this update, we may write $\lambda c\{w + [s_1 \vdash_{w,t} \varphi_t]\ |\ w \in c\}$.

be achieved in various ways. I suggest that the TP introduces a propositional discourse referent (cf. Krifka 2013), which identifies the core proposition that is to be communicated (cf. also Murray & Starr 2020). This aspect of interpretation is not captured in the present modelling.

The core proposition φ_t itself can become part of the context set if the addressee acknowledges the speaker's attempt, e. g. by *okay* or by nodding, or by not objecting to it. Here, the commitment of the speaker s_1 is the reason why the addressee s_2 accepts the core proposition φ_t in the context set. Thus, communication of the core proposition is a conversational implicature (see also Section 2.4).

JP modifiers like *probably* allow the speaker s_1 to communicate the TP proposition φ_t while committing to another one, e. g. that s_1 considers φ_t likely. This is how it works:

(14) $c_0 +_{s_1,s_2,t_0} [_{ActP} [_{ComP} [_{JP} [_{J'}\ \textit{probably}[_{J'} [_{J^0}\ J\text{-}]\ [_{TP}\ \textit{Max arrived}]]]]]]^{s_1,s_2,t_0}$

$= \{w \in c_0 \mid s_1 \vdash_{w,t_0} \lambda w\ [P_{s_1,w,t}(\varphi_{t_0}) > 0.5]\}$

The speaker s_1 commits to the proposition that s_1 considers φ_{t_0} likely. This proposition cannot easily be disputed by s_2 because s_2 does not have access to the epistemic attitudes of s_1. The plausible purpose of this commitment is that s_1 wants to communicate the TP proposition φ_{t_0} as relevant, following a rule that if a reasonable epistemic source considers a proposition possible or even likely, it should be taken into account (cf. Faller 2019). The commitment of s_1 that motivates this step, however, is weaker – s_1 might express that he or she is certain or considers the proposition probable, or, in the case of reportative evidentials, that some other relevant source is committed to the proposition.

2.3 Commitment Spaces

In contrast to assertions, questions do not add information to the CG but indicate the ways how it should be enriched. The question *Did Max arrive?* indicates an interest whether the input CG can be enriched by the proposition that Max arrived; the question *Who arrived?* indicates an interest which of the propositions of the form 'x arrived', x ranging over persons, can enrich the CG. This can be modelled by taking the possible continuations of the commitment state into account. This leads to the notion of Commitment Spaces (CS) as sets of commitment states (cf. Cohen & Krifka 2014, Krifka 2015).

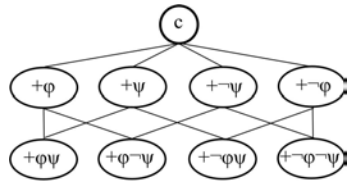
(15) a. A commitment space C is a set of non-empty commitment states.

b. If c, c′ ∈C and c′ ⊂ c then c′ is a possible continuation of c in C.

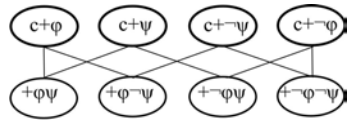
c. √C, the root of C, is defined as {c∈C | ¬∃c′∈C [c⊂c′]}

The root of C is the set of the least specific, i. e. largest commitment states in C.[5] CSs will be illustrated by Hasse diagrams in which the continuations and the root are highlighted as in (16)(a) for a single-rooted and in (b) for a multiple-rooted CS. Simultaneous update with +φ and +¬φ is not possible, as this would lead to the contradictory empty state. Also, pragmatic contradictions like CSs that admit both s⊢φ and ¬φ are ruled out; it is not possible that in one and the same CS, a participant is both committed to s and allows for ¬φ.

(16) a. Single-rooted CS



b. Multi-rooted CS



In a single-rooted CS, the root {c} contains the information that is accepted by the interlocutors; in a multiple-rooted CS, there are alternative CGs, the choice between which is still unresolved. The continuations are the alternatives how this information should preferably develop.

5 The root is restricted to singletons in Krifka (2015), but here we allow for multi-rooted CSs.

2.4 Assertions

Assertive update has to be adapted to Commitment Spaces, that is, should be expressed as a function from an input CS to an output CS. This is achieved by (17), and exemplified in (18).

(17) $[\![[_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^\circ}\ \bullet\ ]\ [_{\text{ComP}}\ \dots]]]]\!]^{s,a,t} = [\![\bullet]\!]^{s,a,t}([\![[_{\text{ComP}}\ \dots]]\!]^{s,a,t})$

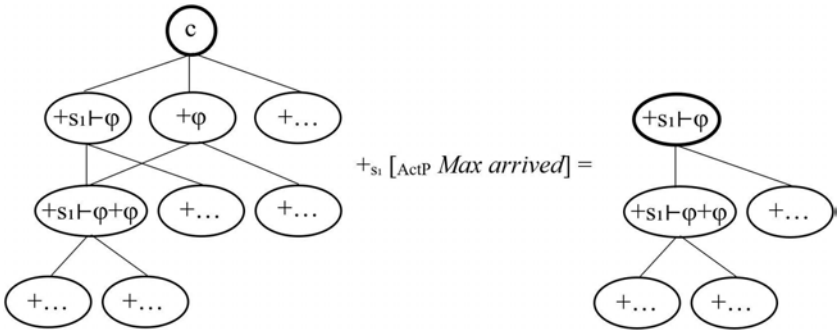
$= \lambda C\ \{c \in C \mid c \subseteq [\![[_{\text{ComP}}\ \dots]]\!]^{s,a,t}(s)\}$

(18) $C_0 +_{s_1,s_2,t_0} [_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^\circ}\ \bullet\ ]\ [_{\text{ComP}}\ [_{C'}\ [_{C^\circ}\ \vdash\ ]\ [_{\text{JP}}\ [_{\text{J}'}\ [_{\text{J}^\circ}\ \text{J-}]\ [_{\text{TP}}\ \textit{Max arrived}]]]]]]]$

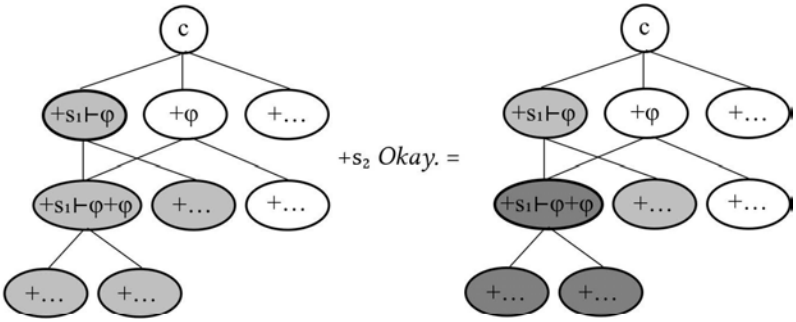
$= \{c \in C_0 \mid c \subseteq \lambda w[s_1 \vdash_{w,t_0} \varphi_{t_0}]\}$

This restricts the input C_0 to those commitment states that contain the information that speaker s_1 is committed to the proposition that Max arrived. See the illustration in (19) or (20)(a), which shows both the input CS and the output CS, in grey. After acceptance by s_2, signaled by *Okay* or nodding, the CS is updated with the communicated proposition φ itself, resulting in the indicated CS in which the proposition that s_1 is committed to φ, as well as φ itself, are established, cf. (20)(b).

(19) Update of CS with assertion

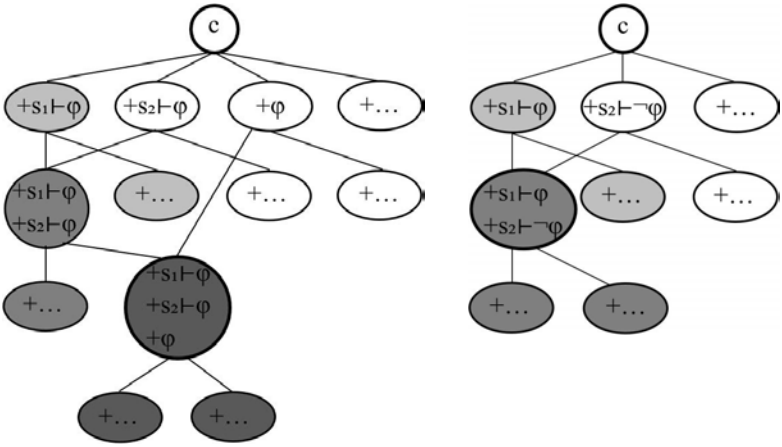


(20) a. Update of CS with assertion b. Further update with proposition



Acceptance as in (20) has to be distinguished from confirmation as in (21)(a), which expresses a commitment by s_2. This also leads to the establishment of the core proposition φ. Contradiction as in (21)(b) commits s_2 to the negation of the proposition, which prevents φ from becoming part of the CS. The resulting CS will contain the information that s_1 and s_2 differ in their commitments about the proposition φ.

(21) a. Confirmation by s_2: *Yes.* b. Contradiction by s_2: *No.*



Thus, the current model keeps a permanent record about which participant is committed to which proposition. In this it differs from Farkas & Bruce (2010) and Farkas & Roelofsen (2017), for whom the CG expresses shared commitments to simple propositions like φ_{t_0}, and the commitments of the individual participants only play a role in the process of getting propositions into the CG.

2.5 Monopolar Questions

With a question, a speaker can indicate a preferred way how the CG should develop, typically by checking whether the addressee would commit to a particular proposition. There are different ways and strategies to ask questions. With a simple polar question *Did Max arrive?* a speaker tests whether the addressee would commit to the proposition 'Max arrived'. We model such questions by an ActPhrase with an interrogative operator ?. The finite verb, which cannot be a main verb in English, moves to the specifier of the ActP:

(22) $[_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^\circ}\ ?\ \textit{did}_0\ ]\ [_{\text{ComP}}\ [_{\text{C}'}\ [_{\text{C}^\circ}\ \vdash]\ [_{\text{JP}}\ [_{\text{J}'}\ [_{\text{J}^\circ}\ \text{J-}]\ [_{\text{TP}}\ \textit{Max arrive}\ t_0]]]]]]]$

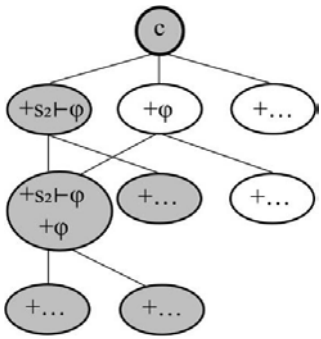
The question operator ? is interpreted as in (23), where the differences to the assertion operator •, cf. (17), are highlighted.

(23) $[\![[_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^\circ}\ ?\ ]\ [_{\text{ComP}}\ \dots]]]]\!]^{s,a,t} = [\![?]\!]^{s,a,t}([\![[_{\text{ComP}}\ \dots]]\!]^{s,a,t})$
$= \lambda C\ [\sqrt{\mathbf{C}} \cup \{c \in C \mid c \subseteq [\![[_{\text{ComP}}\ \dots]]\!]^{s,a,t}(\mathbf{a})\}]$

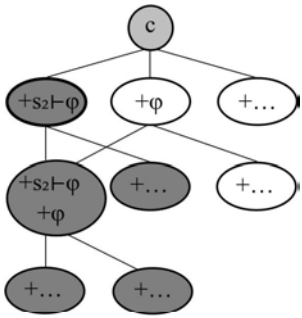
Assuming an input CS C_0, a speaker s_1, addressee s_2 and an utterance time t_0 we have (24), illustrated in (25)(a).

(24) $C_0 +_{s_1,s_2,t_0} [_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^\circ}\ ?\ \textit{did}_0\ ]\ [_{\text{ComP}}\ [_{\text{C}'}\ [_{\text{C}^\circ}\ \vdash]\ [_{\text{JP}}\ [_{\text{J}'}\ [_{\text{J}^\circ}\ \text{J-}]\ [_{\text{TP}}\ \textit{Max arrive}\ t_0\ ]]]]]]]$
$= \lambda C\ [\sqrt{C} \cup \{c \in C \mid c \subseteq \lambda w\ [s_2 \vdash_{w,t_0} \varphi_{t_0}]\}]$

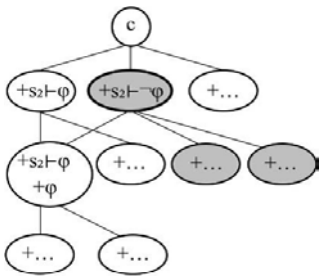
(25) a. Update of CS by *Did Max arrive?*



b. Confirming answer *Yes.*



c. Rejecting answer *No.*: Going back to original CS committing to negation.



In contrast to assertions, the root does not change with a question, cf. (25)(a). The speaker s_1 restricts the continuations to the commitment by s_2 to the proposition. The confirming answer *yes* by s_2 leads to the CS in (25)(b). As for the negative answer, notice that the commitment $s_2 \vdash \neg\varphi_t$ cannot be expressed after the interrogative update (25)(a). In such cases the interrogative update is retracted, going back to the original CS, and the commitment $s_2 \vdash \neg\varphi_{t_o}$ is added,

as in (25)(c). This retraction is modelled in Krifka (2015) with the help of a stack of CSs that correspond to the development of a conversation. In general, a participant, here s_2, can reject a proposed change of the CS if it enforces a commitment or action by that participant, leading to a retraction of the last move.[6]

In the current analysis, a polar question does not offer an alternative between two propositions, like in most other approaches (e.g., Hamblin 1973, Groenendijk & Stokhof 1984, Farkas & Roelofsen 2017 and Ciardelli et al. 2018). Rather, one proposition is more prominent, as it can be answered without retraction of the proposed extension. As this representation has a bias, it can be called *monopolar*. Such readings of simple polar questions have been proposed by Roberts (1996), Biezma & Rawlins (2012), and Uegaki (2014).

2.6 Alternative and bipolar questions

One reason for assuming a monopolar interpretation of simple polar questions is that this allows for a straightforward analysis of alternative questions:

(26) a. *Did Max arrive or did Sue arrive?*

b. *Did Max or Sue arrive?*

(27) a. *Did Max arrive, or did he not arrive?*

b. *Did Max arrive or not?*

In their alternative question interpretation, which involves rising accent on one alternative constituent and falling accent on the other (cf. Bartels 1999, Pruitt & Roelofsen 2013), such questions can be interpreted as disjunctions on the level of the ActPhrase, as union over the individual updates, cf. (28):

(28) $[\![[_{\text{ActP}}\ [_{\text{ActP}}\ \alpha]\ \textit{or}\ [_{\text{ActP}}\ \beta]]]\!]^{s,a,t}$

$= [\![\textit{or}]\!]([\![[_{\text{ActP}}\ \alpha]]\!]^{s,a,t})([\![[_{\text{ActP}}\ \beta]]\!]^{s,a,t})$

$= \lambda A \lambda A' \lambda C\ [A(C) \cup A'(C)]([\![[_{\text{ActP}}\ \alpha]]\!]^{s,a,t})([\![[_{\text{ActP}}\ \beta]]\!]^{s,a,t})$

$= \lambda C\ [[\![[_{\text{ActP}}\ \alpha]]\!]^{s,a,t}(C) \cup [\![[_{\text{ActP}}\ \beta]]\!]^{s,a,t}(C)]$

6 The possibility of rejecting the last move has a similar function as the negotiating table in Farkas & Bruce (2010): It regulates what finally enters the CG. However, in the current framework, rejecting answers to simple polar questions require a more complex mechanism.

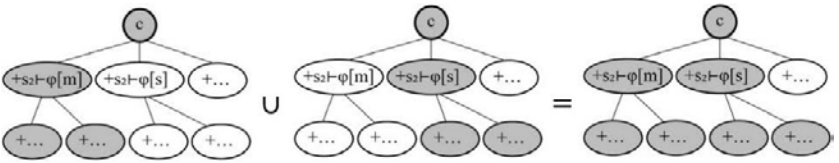
For illustration, consider the following update of a CS with (26)(a), where $\varphi_t[x]$ stands for the proposition that x arrived before t, i. e. $\lambda w \exists t' [t' < t \wedge \text{arrived}_{w,t'}(x)]$.[7]

(29) $C_0 +_{s_1,s_2,t_0} [_{\text{ActP}} [_{\text{ActP}}$ *did Max arrive*$]$ *or* $[_{\text{ActP}}$ *did Sue arrive*$]]$

$= \sqrt{C_0} \cup \{c \in C_0 \mid c \subseteq \varphi_{t_0}[m]\} \cup \{c \in C_0 \mid c \subseteq \varphi_{t_0}[s]\}$

(30) Disjunction of two interrogative updates,

Did Max arrive or did Sue arrive?



Alternative questions come with the pragmatic presupposition that one of the alternants is true. This is expressed by the disjunctive interpretation provided here. If we model each disjunct question, *Did Max arrive?* and *Did Sue arrive?* as allowing equally easily an affirmative and a rejecting answer, then we would not predict this pragmatic presupposition, as the situation where both alternants are false would be as good an option as the others.

Alternative questions with a constituent disjunction like (26)(b) can be analyzed as involving a type-lifted ActP disjunction. The disjunctive constituent, here Max or Sue, moves from within the TP, leaving a trace.

(31) $[\![[_{\text{ActP}} [_{\text{DP}}$ *Max or Sue*$]$ $_x[_{\text{Act}'}$ *did* t_x *arrive*$]]]\!]^{s,a,t}$

$= [\![[_{\text{DP}}$ *Max or Sue*$]]\!]^{s,a,t}$ $([\![_x[_{\text{ActP}}$ *did* t_i *arrive*$]]\!]^{s,a,t})$

$= \lambda A \lambda C$ [A(m)(C) ∪ A(s)(C)]$(\lambda x \lambda C$ [$\sqrt{C} \cup \{c \in C \mid c \subseteq \lambda w[a \vdash_{w,t} \varphi_t[x]]\}$)

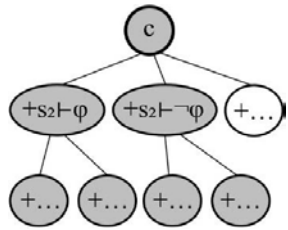
$= \lambda C$ [$\sqrt{C} \cup \{c \in C \mid c \subseteq \lambda w[a \vdash_{w,t} \varphi_t[m]]\} \cup \{c \in C \mid c \subseteq \lambda w[a \vdash_{w,t} \varphi_t[s]]\}$]

$= \lambda C$ [$\sqrt{C} \cup \{c \in C \mid c \subseteq \lambda w[a \vdash_{w,t} \varphi_t[m]] \vee c \subseteq \lambda w[a \vdash_{w,t} \varphi_t[s]]\}$]

7 For the additional accent marking, *Did /MAX arrive or did \SUE arrive?* cf. Kamali & Krifka (2020).

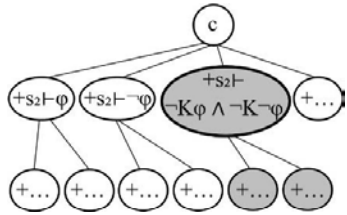
True bipolar questions can be expressed by alternative questions like (27), resulting in interpretation (32). The parts *did Max* and *arrive* can be suppressed. This is a question without bias, see the illustration on the margin in comparison to (25)(a). Speaker s_2 can answer in the affirmative or negative, without going back to the previous CS.

(32) $C_0 +_{s_1,s_2,t_0} [_{ActP} [_{ActP}$ *did Max arrive*$]$ *or* $[_{ActP}$ *not*$]] = \sqrt{C_0} \cup \{c \in C_0 \mid c \subseteq \lambda w\, [s_2 \vdash_{w,t_0} \varphi_{t_0}] \vee c \subseteq \lambda w\, [s_2 \vdash_{w,t_0} \neg\varphi_{t_0}]\}$

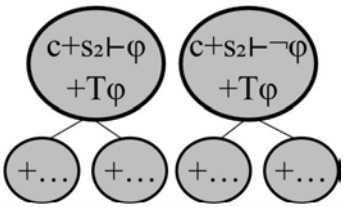


One remark about the architecture of CSs: The grey CS in (32) does not include continuations other than $s_2 \vdash \varphi$ and $s_2 \vdash \neg\varphi$. One possible reaction is that s_2 asserts not knowing the answer, expressing the commitment $s_2 \vdash [\neg K\varphi \wedge \neg K\neg\varphi]$. As this proposition is pragmatically incompatible with $s_2 \vdash \varphi$ and $s_2 \vdash \neg\varphi$, the last move must be retracted first before the update is possible, cf. (33)(a). It is also possible that s_2 makes some other assertion, like *I will think about it*, for which we write $s_2 \vdash T\varphi$, resulting in a multiple rooted CS in which the question needs to be resolved in order to reduce the roots, cf. (33)(b).

(33) a. s_2: *I don't know.*



b. s_2: *I will think about it.*



2.7 Question Bias and the Monopolar Analysis

We have modelled simple polar questions, polar questions with negated core propositions and alternative questions built from them as in (34)(a,b,c), respectively.

(34) a. $[\![\textit{Did Max arrive?}]\!]^{s,a,t}$
$= \lambda C\,[\sqrt{C} \cup \{c \in C \mid c \subseteq \lambda w\,[s_2 \vdash_{w,t} \varphi_t]\}]$

b. $[\![\textit{Did Max not arrive?}]\!]^{s,a,t}$
$= \lambda C\,[\sqrt{C} \cup \{c \in C \mid c \subseteq \lambda w\,[s_2 \vdash_{w,t} \neg\varphi_t]\}]$

c. $[\![\textit{Did Max arrive or not?}]\!]^{s,a,t}$
$= \lambda C\,[\sqrt{C} \cup \{c \in C \mid c \subseteq \lambda w\,[s_2 \vdash_{w,t} \varphi_t] \vee c \subseteq \lambda w\,[s_2 \vdash_{w,t} \neg\varphi_t]\}$

The monopolar question (34)(a) checks whether the addressee would commit to 'Max arrived', whereas the monopolar question with negated proposition (b) checks whether the addressee would commit to its negation, 'Max did not arrive'. Contrary answers require the retraction of the proposed continuation, and hence would be more complex than agreeing answers. Only the bipolar alternative question (c) allows for either answer without retraction. In this sense, (34)(a) is biased to the answer *Max arrived*, (b) is biased to *Max didn't arrive*, and only (c) is biased towards neither answer. For the classical bipolar analyses of simple polar questions the meanings of (34)(a,b,c) are identical.

The classical analyses face the problem that simple polar questions and alternative questions are used in different circumstances. For example, Bolinger (1978) points out (35)(a) is a good question for a speaker interested in marriage, whereas (b) is not.

(35) a. Will you marry me? b. Will you marry me or not?

For factual information questions, Büring & Gunlogson (2000) argue that positive polar questions are not felicitous if there is contextual evidence against the core proposition, and AnderBois (2011) shows that negated polar questions require a negative expectation towards the core proposition. The experimental studies of Roelofsen et al. (2013) and Domaneschi et al. (2017) support the conclusion that speakers avoid reversing responses, given contextual evidence, and prefer the least marked form. Domaneschi et al. (2017) investigate combinations of neutral (0), positive (+) and negative (–) prior expectation and contextual evidence for a proposition φ and find that the (0|+) case (neutral prior expectation, positive contextual evidence) favors positive polar questions and the (0|–) case favors negated polar questions;[8] the (0|0) case favors the unmarked positive polar questions. Avoiding reversing responses is also seen with lexical choices; Trinh (2014) points out that the question *Is Max married?* presupposes that there is contextual evidence that Max is married, which makes the question *Is Max single?* infelicitous in this context.

As for alternative questions like (34)(c) and (35)(b), Biezma (2009) points out that alternative questions of this type are fine if they come late in a series of questions, with the pragmatic effect of ›cornering‹ the addressee into one or the other answer. All these observations are difficult to explain if the questions in (34) have the same interpretation.

Theories that do not assume a monopolar analysis of simple polar questions must deal with their bias in other ways. The examples (34) differ in their syntax, which may differentiate their uses. Roelofsen & van Gool (2010) assume that in (34)(a), the proposition 'Max arrived' is "highlighted"; Farkas & Roelofsen (2017) propose that this highlighting is mediated by the introduction of propositional discourse referents.

However, it is not clear whether discourse referents are sufficient to express bias. Krifka (2013) proposes that the TP as well as the syntactic phrase that expresses negation (NegP) introduces a propositional discourse referent. Using an informal representation, where $\downarrow\varphi_t$ indicates that the constituent above introduces a discourse referent for the proposition φ_t, we have the discourse representations in (36).

8 Negated questions also occur in the (+|–) case but are outnumbered by high negation questions, cf. section 2.8. Positive questions also occur in the (–|+) case but participants more often selected questions marked by *really*. This can be explained under the assumption that *really* is a ComP marker that requests a higher level of commitment.

(36) a. [Did_0 [$_{TP}$ *Max* t_0 *arrive*]]?
↳ φ_t

b. [Did_0 [$_{NegP}$ Max_1 *not* [$_{TP}$ t_1 t_0 *arrive*]]]?
↳ $\neg\varphi_t$ ↳ φ_t

Response particles are anaphors to such discourse referents that assert them (*yes*) or their negation (*no*). For (36)(a) one could construct a bias towards the positive answer (that Max arrived) because this answer can be expressed by the confirming response particle (*yes*), whereas the negative answer requires the more complex operation of negation (*no*). However, the presence of discourse referents does not explain why (36)(b) is biased towards the proposition that Max did not arrive. Both discourse referents $\neg\varphi$ and φ are equally accessible, cf. reactions like *No, he didn't* (addressing φ_t) and *Yes, he didn't* (addressing $\neg\varphi_t$) (cf. Krifka 2013, Farkas & Roelofsen 2017, 2019, Claus et al. 2017). So it appears that propositional discourse referents are not sufficient to capture the bias of questions with negated propositions like *Did Max not arrive?*.

It should be noted that bias of a polar question towards a proposition p does not mean that the speaker considers p more likely than ¬p. The speaker might consider p more informative, and hence less likely, than ¬p (cf. van Rooy & Šafářová 2003). This is the case if there is a prior expectation by the speaker that p is not the case but now there is evidence that p might hold (cf. Sudo 2013, Gärtner & Gyuris 2017). The speaker also might have no prior opinion about p and there is no contextual evidence, but p calls for action and ¬p does not, as in *Is Max infected?*.

2.8 High Negation Questions

There is a syntactically distinct case of a negation in questions, as in (37) (cf. Ladd 1981).

(37) *Didn't Max arrive?*

Actually, (37) is ambiguous between a ›low‹ propositional negation reading and a ›high‹ non-propositional reading, which can be distinguished with negative polarity items:

(38) a. *Didn't Max arrive either?* (≈ *Did Max not arrive either?*)
low negation

b. *Didn't Max arrive too?*

high negation

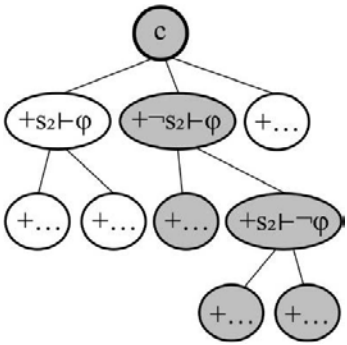
Several theories have been developed to capture the pragmatic function(s) of high negation questions, cf. Romero (2005) for an interaction with a VERUM operator, Repp (2013) for an interaction with a FALSUM operator, Goodhue (2019) for interaction with an epistemic operator, and Asher & Reese (2007), who assume a combination of a question and an assertion.

As already observed by Ladd (1981), high negation is not part of the core proposition. The interpreted syntactic structure proposed here offers a place where it can be interpreted without assuming additional operators, namely as negation of commitments, exemplified in (39) and illustrated to the right (cf. Krifka 2015). This corresponds to the syntactic position of the negation in this case.

(39) $[\![[_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^\circ}\ \textit{did}_i?]\ [_{\text{ComP}}\ \textit{n't}\ [_{\text{ComP}}\ [_{\text{C}'}\ [_{\text{C}^\circ}\ \vdash]$

$[_{\text{JP}}\ [_{\text{J}'}\ [_{\text{J}^\circ}\ \text{J-}]\ [_{\text{TP}}\ \textit{Max}\ t_i\ \textit{arrive}]]]]]]]]]\!]^{s,a,t}$

$= \lambda C\ [\surd C \cup \{c \in C \mid c \subseteq \lambda w\ [\neg s_2 \vdash_{w,t} \varphi_t]\}]$



As for the pragmatics of high negation questions, we have to compare them with the positive question, *Did Max arrive?* as well with the low-negation question, *Did Max not arrive?*. Compared to checking whether s_2 commits to φ or commits to ¬φ, checking whether s_2 does not commit to φ at t_0 puts a lighter burden on s_2, as s_2 is not required to make any commitment in this issue. The output CS of (39) allows for negative assertions (*Max didn't arrive*) as well as for avoiding assertions (e.g. by expressing ignorance, *I don't know*). Affirming assertions (*Max did arrive*) require going back to the initial CS.

This corresponds to the experimental results of Roelofsen et al. (2013) and Domaneschi et al. (2017). The latter show that high negation questions are preferred in case of prior expectation that the proposition is true (strongly in the (+|0) case but also in the (+|–) case, where low negation questions are an option, too). This is the strategy of speakers that seek confirmation of prior expectations, and facilitates the answer that runs against the prior expectations, as this answer would provide the highest informational gain.

2.9 Constituent Questions

Constituent questions are interpreted like alternative questions. The wh-constituent is similar to a disjunctive phrase like *Max or Sue* in (31), where the wh-constituent expresses a restriction over the type of entities, e. g. *who* for persons and *when* for times.

(40) $[\![[_{\text{ActP}}\ \textit{who}\ _i[_{\text{Act}'}\ t_i\ \textit{arrived}]]]\!]^{s,a,t}$

$= [\![\textit{who}]\!]^{s,a,t}\ ([\![_i[_{\text{Act}'}\ t_i\ \textit{arrived}]]\!]^{s,a,t})$

$= \lambda A \lambda C\ [\cup_{x \in \text{PERSON}}\ A(x)(C)]\ (\lambda x \lambda C\ [\surd C \cup \{c \in C \mid c \subseteq \lambda w\ [a \vdash_{w,t}\ \varphi_t[x]]\}])$

$= \lambda C\ [\surd C \cup \{c \in C \mid \exists x \in \text{PERSON}\ [c \subseteq \lambda w\ [a \vdash_{w,t}\ \varphi_t[x]]\}]$

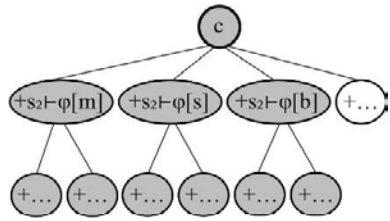
Assume that there are three persons under discussion, Max, Sue, and Bill, and let s_2 be the addressee. We then get the interpretation (41).

(41) $\lambda C\ [\surd C \cup$

$\{c \in C \mid c \subseteq \lambda w\ [s_2 \vdash_{w,t_0}\ \varphi_{t_0}[m]\} \cup$

$\{c \in C \mid c \subseteq \lambda w\ [s_2 \vdash_{w,t_0}\ \varphi_{t_0}[s]\} \cup$

$\{c \in C \mid c \subseteq \lambda w\ [s_2 \vdash_{w,t_0}\ \varphi_{t_0}[b]\}]$



This analysis generalizes to multiple constituent questions, like *Who ate what?* where we assume that all wh constituents undergo wh movement. For the modelling of the various readings of such questions cf. Kamali & Krifka (2020).

Our analysis of assertions in (17), of polar questions in (23) and of constituent questions in (40) provides for a new take on the issue of Frege (1918) whether

assertions and questions have propositions as their core semantic objects. Assertions and polar questions do, and constituent questions are disjunctive quantifications over polar questions.

We have derived a biased question meaning for simple polar questions like *Did Max arrive?*, and have seen that there are arguments for doing so. However, such questions can also be used in an epistemically unbiased context. For example, in a game of guessing the outcome of a throw of dice, (42) is adequate even without prior speaker expectation.

(42) [Guessing results of dice rolls:] *Is it an odd number?*

How can we reconcile this with the suggested monopolar interpretation? One strategy is to stick to the literal biased interpretation and explain why this is nevertheless the optimal option in this context: It is simpler than the non-biased questions *Is it an odd number or not?* and *Is it not an odd number?* And it is equally good as the question *Is it an even number?*.

Kamali & Krifka (2020) offer another proposal. Let us first consider a question with focus on the subject. Our standard example would have the interpretation in (43).

(43) $[\![[_{\text{ActP}}\ \textit{Did}\ ?\ [_{\text{ComP}} \vdash [_{\text{TP}}\ \textit{MAX}_{\text{F}}\ \_\ \textit{arrive}]]]]\!]^{s,a,t}$

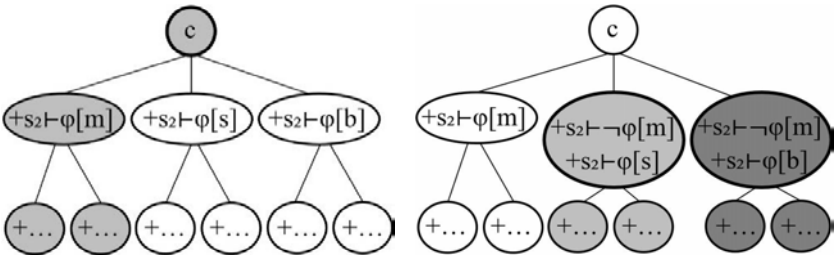
condition on input CS

$= \lambda C\ .\ C = \surd C \cup \bigcup_{x \in ALT(m)} \{c \in C \mid c \subseteq \lambda w\ [a \vdash_{w,t} \varphi_t[x]\} \ .\ \{c \in C \mid c \subseteq \lambda w\ [a \vdash_{w,t} \varphi_t[x]\}$

Focus expresses a condition on the input CS C that the question for which x, where x are alternatives to Max, the addressee would commit to the proposition that x arrived. It is as if the question *Who arrived?* had been asked. The affirming answer *yes* is straightforward, cf. (44)(a). The rejecting answer *no* requires backtracking to the previous CS, where update with the commitment by the addressee that Max did not arrive leads to a multiply rooted CS that requests further information, cf. (44)(b). Therefore, *no* is incomplete, and requires completion by, for example, SUE_{F} *did*, represented by the dark area in (44)(b).

(44) a. Input condition
+ *Did MAX*$_F$ *arrive?*

b. Rejecting answer *No, Bill did.*



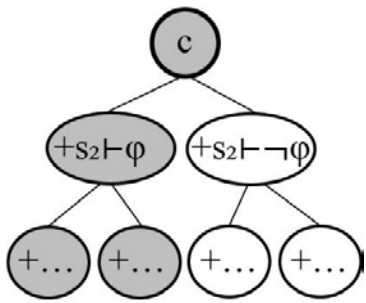
For polar questions, Kamali & Krifka (2020) assume an optional polarity operator λp.p with alternatives {λp [p], λp [¬p]}. For English, this operator is plausibly related to the finite auxiliary verb, e. g. *did*. This results in an input CS condition that a bipolar question is asked, of which one alternative, the positive one, is singled out. (45) indicates a possible derivation with a PolP with head POL to which the past auxiliary *did* moves and where it is focused, and from where it is moved in turn to the head of the ActP.

(45) $[\![[_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^\circ}\ ?\ \textit{DID}_i]\ [_{\text{ComP}}\ \vdash\ [_{\text{PolP}}\ [_{\text{Pol}'}\ [_{\text{Pol}^\circ}\ \text{POS-t}_k]_i]_F$
$[_{\text{TP}}\ \textit{Max}\ \text{PAST}_k\ \textit{arrive}]]]]]]^{s,a,t}$

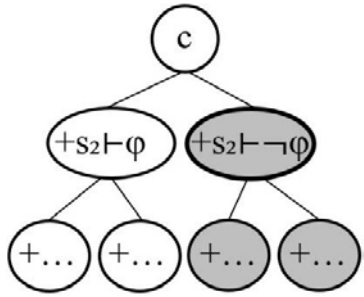
$= \lambda C\ .\ C$

$= \sqrt{C} \cup \bigcup_{M \in \{\lambda p[p],\ \lambda p[\neg p]\}} \{c \in C \mid c \subseteq \lambda w\ [a \vdash_{w,t} M(\varphi_t)\}\ \{c \in C \mid c \subseteq \lambda p\ [p](\lambda w\ [a \vdash_{w,t} \varphi_t)\}$

(46) a. Input condition
+ *DID Max arrive?*



b. *No.*
Retraction and remaining option



The effect of this question is illustrated in (46)(b). If answered negatively, retraction is required, and the only remaining continuation is the commitment by the addressee that Max did not arrive, cf. (46)(b). In this way, questions like (45) are both bi- and monopolar: They presuppose a bipolar question (this is the question that is of interest) and select, more or less arbitrarily, one of the options (this is the monopolar question).

After having discussed polar, alternative, and constituent questions, one issue that naturally arises is whether there is a feature of a CS that indicates whether a question is asked. This is indeed the case: If all the continuations of the root √C of C are enriched by one particular proposition (e.g. $s_2 \vdash \varphi$) or one of a limited set of propositions (like $s_2 \vdash \varphi[x]$, $x \in \{m, s, b\}$) , then C is awaiting the solution to a question.

2.10 Declarative Questions

Declarative questions have the grammatical form of assertions, yet are identified as questions by their high boundary tone (Bartels 1999, Gunlogson 2002, 2008, Trinh 2014, Malamud & Stephenson 2015):

(47) *Max has already arrived?* H%

Such questions are appropriate if the speaker is biased towards a positive answer, i. e. in the (0|+) case. They can contain epistemic operators that do not occur in regular questions, cf. (48). Yet they are questions because they do not result in a commitment by the speaker, cf. (49).

(48) a. *#Did Max certainly / probably arrive already?*

b. *Max has certainly / probably arrived already?*

(49) s_1: *Max has arrived already?*

s_2: *#You are a liar!*

Declarative questions can be modelled by assuming that they express a commitment by the speaker, like assertions. This corresponds to their declarative syntactic structure and to the presence of assertion-specific epistemic operators. However, they express just a proposal for an assertive update insofar as they do not change the root of the input CS. This meaning component is due to the high boundary tone, H% (Bartels 1999):[9]

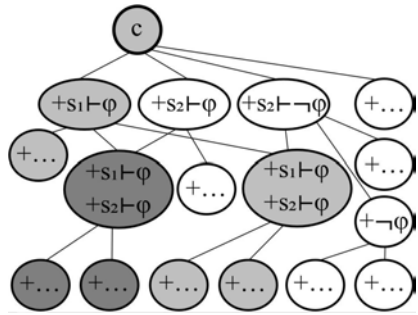
(50) $[\![[_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^\circ}\ \bullet\ ]\ [_{\text{ComP}}\ [_{\text{C}'}\ [_{\text{C}^\circ}\ \vdash\ ]\ [_{\text{JP}}\ [_{\text{J}'}\ [_{\text{J}^\circ}\ \text{J-}]\ [_{\text{TP}}\ \textit{Max arrived}]]]]]]]\ \text{H\%}]\!]^{s,a,t}$

$= \lambda C\ [\sqrt{C} \cup \{c \in C \mid c \subseteq \lambda w\ [s_1 \vdash_{w,t} \varphi_t]\}]$

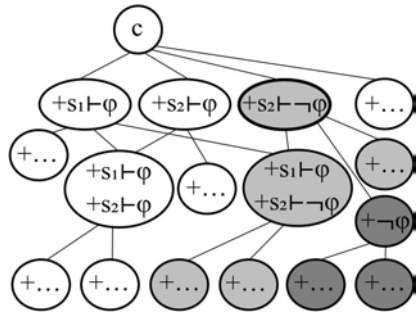
(51)(a) illustrates this declarative question, with a confirming answer resulting in a CS in which both s_1 and s_2 are committed to φ, and φ can be assumed by conversational implicature. The rejecting answer *no* can be interpreted after the declarative question, but would lead to conflicting commitments and block φ. Alternatively, the declarative question can be retracted, allowing for the commitment by s_2 to ¬φ, cf. (b).

9 Regular polar and constituent questions allow for rising and falling boundary tones, where the latter is quite rare (cf. Hedberg et al. 2017). Falling contour questions may be analyzed as propositing a speaker's commitment, just as rising declarative questions, cf. Steedman (2007).

(51) a. s_1: *Max arrived?*,
s_2: *Yes, he did.*



b. s_1: *Max arrived?*,
s_2: *No, he didn't.*



The observation concerning the epistemic adverbials (48) can be explained under the assumption that they are speaker-oriented, and that the addressee cannot express commitments about the speaker's epistemic stances. However, certain epistemic and evidential operators do occur in regular questions, and have been interpreted from the perspective of the addressee ("interrogative flip", cf. Faller 2002, Korotkova 2018, Eckardt 2020). San Roque et al. (2017), in a typological survey, consider interrogative flip an idiomatic property of certain evidential markers.

In English, the epistemic adverb *possibly* can occur in regular polar questions, cf. *Did Max possibly arrive already?*. We predict an addressee-oriented interpretation, cf. (52). A plausible pragmatic motivation is that the speaker invites an agreeing response even in case the addressee does not have conclusive knowledge, which suggests that the speaker has no prior expectation. Hence the use of *possibly* is a de-biasing strategy for monopolar questions.

(52) $[\![[_{\text{ActP}}\ [_{\text{Act}^\circ}\ \textit{Did}_0\ ?]\ [_{\text{ComP}}\ \textit{Max}_1\ [_{\text{C}'}\ [_{\text{C}^\circ}\ \vdash]\ [_{\text{JP}}\ \textit{possibly}\ [_{\text{J}'}\ [_{\text{J}^\circ}\ \text{J-}]\ [_{\text{TP}}\ t_1\ t_0\ \textit{arrive}]]]]]]]\!]^{s,a,t}$
$= \lambda C\ [\sqrt{\mathbf{C}} \cup \{c \in C \mid c \subseteq \lambda w\ [\mathbf{a/s+a} \vdash_{w,t} P_{i,w,t}(\varphi_t) > 0]\}]$

Alternatively, we can allow for so-called "conjectural" questions that involve the judgement of both speaker and addressee (cf. Eckardt 2020 for German *wohl*). For this, the interpretation of ? in (23) can include the addressee, allowing for the sum s+a as judge.[10]

2.11 Root Questions and Embedded Questions

As it is well-known, interrogative sentences do not only express the speech act of questions but also occur in embedded clauses:

(53) a. *Sue knows whether Max arrived.*
b. *Sue knows who arrived.*

Question semantics has taken off from the meaning of embedded interrogatives because they contribute to the truth conditions of the whole sentence, and semantics focused on the derivation of truth conditions. For example, there is an entailment relation between *Sue knows that Max arrived* and *Sue knows who arrived*. Under a model of question meanings as sets of propositions, we can assume syntactic and semantic representations as in (54) (where CP is the syntactic category of a complementizer phrase).

(54) a. $[\![[_{\text{CP}}\ \textit{whether}\ [_{\text{TP}}\ \textit{Max arrived}]]]\!]^{s,a,t} = \{\varphi_t, \neg\varphi_t\}$
b. $[\![[_{\text{CP}}\ \textit{who}_x [_{\text{TP}}\ t_x\ \textit{arrived}]]]\!]^{s,a,t} = \{\varphi_t[m], \varphi_t[s], \varphi_t[b]\}$

If we assume that *know* has a basic meaning taking a proposition as an argument, the interrogative-denoting meaning of *know* can be derived from that: To ›know‹ a set of propositions P is to know for every proposition p∈P that are true that p is true.

10 E.g., by $\lambda C\ [\sqrt{C} \cup \{c \in C \mid \exists x[a \sqsubseteq x \wedge c \subseteq [\![[_{\text{ComP}} \ldots]]\!]^{s,a,t}(x)]\}]$ for (23), where $\sqsubseteq$ is the part relation. The preferred and simplest interpretation is a=x, but *possibly* (also *perhaps* and German *vielleicht* and *wohl* as inferential evidentials) must include the speaker as origo, and hence a+s is the best option.

The meaning of (54)(a) and (b) can be derived as in (55).[11] For (55)(b) this is similar to the generation of a root question, cf. (40), except there the wh constituent scopes over question acts, expressing a disjunction over individual acts.

(55) a. $[\![[_{CP}\ \textit{whether}\ [_{TP}\ \textit{Max arrived}]]]\!]^{s,a,t}$

$= [\![\textit{whether}]\!]^{s,a,t}([\![[_{TP}\ \textit{Max arrived}]]\!]^{s,a,t})$

$= \lambda p\ [\cup_{M\in\{\lambda p\ [p],\ \lambda p\ [\neg p]\}}\{M(p)\}](\varphi_t) = \{\varphi_t, \neg\varphi_t\}$

b. $[\![[_{CP}\ \textit{who}_x[_{TP}\ t_x\ \textit{arrived}]]]\!]^{s,a,t}$

$= [\![\textit{who}]\!]^{s,a,t}\ ([\![_x[_{TP}\ t_x\ \textit{arrived}]]\!]^{s,a,t})$

$= \lambda r\ [\cup_{x\in PERSON}\{r(x)\}](\lambda x\ [\varphi_t[x]]) = \cup_{x\in PERSON}\{\varphi_t[x]\}$

Now, it would be possible to derive a question ActP from an embedded question, assuming the following structure and interpretation:

(56) $[\![[_{ActP}\ [_{Act'}\ [_{Act^\circ}\ ?]\ [_{ComP}\ [_{Com'}\ [_{Com^\circ}\ \vdash]\ [_{CP}\ \textit{who}_i[_{TP}\ t_i\ \textit{arrived}]]]]]]]\!]^{s,a,t}$

$= [\![?]\!]^{s,a,t}([\![\vdash]\!]^{s,a,t}([\![[_{CP}\ \textit{who}_i[_{TP}\ t_i\ \textit{arrived}]]]\!]^{s,a,t})))$

$= \lambda P\lambda C\ [\sqrt{C} \cup \{c\in C \mid \exists p\in P[c\subseteq p]\}](\lambda P'\ \{\lambda w\ [a\vdash_{w,t} p] \mid p\in P'\}(\cup_{x\in PERSON}\{\varphi_t[x]\}))$

As the CP denotes a set of propositions, the commitment operator $\vdash$ has to be type-lifted to apply to such sets, and the question operator ? applies to a set of propositions. This works, but is more complex than the direct derivation of root questions in (40). Furthermore, it is not clear how to derive the distinction of embedded vs. root syntax with nonsubject constituent questions, such as $[_{ActP}$ *When did Max arrive?*] vs. $[_{CP}$ *when Max arrived*]. And for polar questions, embedded questions differ from root questions by the presence of a

11 Alternatively, *wh*-constituents can be decomposed, e. g. wh+o, wh+at, wh+en, with a wh component that expresses disjunction $\cup$, and the remnant that expresses a semantic restriction of the trace. (54)(b) is derived as in (i) (with F an appropriate function variable). For (54)(a) we can assume (ii) (with T a variable for truth values)

(i) $[\![[_{CP}\ \textit{wh-}_x[_{TP}\ o_x\ \textit{arrived}]]]\!]^{s,a,t} = \lambda F\ [\cup_{x\in DOM(F)}\{F(x)\}](\lambda x\in PERSON[\varphi_t[x]])$
$= \cup_{x\in PERSON}\{\varphi_t[x]\}$

(ii) $[\![[_{CP}\ \textit{wh-}\ [_{PolP}\ \textit{e(i)ther}\ [_{TP}\ \textit{Max arrived}]]]]\!]^{s,a,t}$
$= \lambda F\ [\cup_{x\in DOM(F)}\{r(x)\}]\ (\lambda p\lambda T\in\{0,1\}\lambda w\ [p(w)=T](\varphi_t)) = \{\lambda w\ [\varphi_t(w)=0], \lambda w\ [\varphi_t(w)=1]\}$

complementizer, *whether*. This argues against a derivation in which embedded questions feed root questions.

However, one phenomenon that seems to argue for the derivation (56) are anaphoric uptakes like the following (pointed out by Ivano Ciardelli, pers. comm.):

(57) s_1: *Who arrived?*
s_2: *I don't know* {*Ø / that / it*} *but Sue knows* {*Ø / that / it*}.

The representation (56) provides for a semantic object as antecedent of *that*, *it* or the null anaphor, namely the CP meaning, whereas the representation (40) appears to lack such an antecedent. However, a closer look at the derivation reveals that the TP from which the wh-constituent is extracted can be interpreted as a function from entities (restricted to persons) to propositions; if the TP introduces a discourse referent with this meaning, this can serve as an antecedent for the subsequent discourse:

(58) $[\![[_{\text{ActP}}\ \textit{who}_x [_{\text{Act}'}\ [_{\text{Act}^\circ}\ ?]\ _x[_{\text{ComP}}\ x [_{\text{Com}'}\ [_{\text{Com}^\circ}\ \vdash]$ $\quad {}_x[_{\text{TP}}\ t_x\ \textit{arrived}]]]]]]]^{s,a,t}$
$\quad \hookrightarrow \lambda x \in \text{PERSON} \varphi_t[x]$

This strategy would not work with the derivation of polar questions as in (23), as they do not involve extraction. Yet the same type of anaphoric uptake is possible, cf. (59)(a).

(59) s_1: *Did Max arrive?*
a. s_2: *I don't know* {*Ø / that / it*} *but Sue knows* {*Ø / that / it*}.
b. s_2: *I don't think so. / I don't believe it / that.*

But note that anaphoric uptake of the proposition φ_t is possible as well, cf. (59)(b), which is difficult to reconcile with a theory that provides for a bipolar question meaning. This suggests that the question in (59) introduces a propositional discourse referent, as in (60).

(60) $[\![[_{\text{ActP}}\ [_{\text{Act}'}\ [_{\text{Act}^\circ}\ \textit{did}_0\ ?]\ [_{\text{ComP}}\ [_{\text{Com}'}\ [_{\text{Com}^\circ}\ \vdash]$ $\quad [_{\text{TP}}\ \textit{Max}\ t_0\ \textit{arrive}]]]]]]]^{s,a,t}$
$\quad \hookrightarrow \varphi_t[m]$

This propositional discourse referent is taken up by anaphors like *so*, *it*, *that* in (59)(b) (cf. Meijer 2020). It is also taken up in (59)(a), but *know* can select for a proposition or a set of propositions. We can assume a type shift that takes a proposition p and delivers the question meaning {p, ¬p}, thus feeding the second interpretation of *know*. The shift can be attributed to the factivity of proposition-embedding *know*: When, as in (59), the speaker asks whether φ is the case it is certainly not already established that φ is true.

2.12 Deliberative Questions

There is a type of question that does not put the addressee under an obligation to answer but just raises the issue as being of interest. In German, such ›deliberative‹ questions are expressed by questions with verb-final syntax characteristic of embedded questions and the complementizer *ob* and obligatory high boundary tone, as in *Ob Max schon angekommen ist?*, 'The question is, has Max arrived already?' (Truckenbrodt 2006).[12] Such questions can be analyzed as CPs like (55)(a), corresponding to their syntactic structure, that receive their discourse function by the high boundary tone H%. The input CS is enriched by the propositions in the CP, which leads to a CS with multiple roots, cf. (62)(a).

(61) $[\![[_{CP}\ ob\ [_{TP}\ Max\ angekommen\ ist]]\ H\%]\!]^{s,a,t}$

$= [\![H\%]\!]^{s,a,t}([\![[_{CP}\ ob\ [_{TP}\ Max\ angekommen\ ist]]]\!]^{s,a,t})$

$= \lambda S\ (\lambda C\ \cup_{p \in S}\ \{c \subseteq p\ |c \in C\})(\{\varphi_t, \neg\varphi_t\})$

$= \lambda C\ [\{c \subseteq \varphi_t \mid c \in C\} \cup \{c \subseteq \neg\varphi_t \mid c \in C\}]$

(62) a. s_1: *Ob Max angekommen ist?*
'I wonder whether Max arrived.'

b. s_2: *Ja, er ist angekommen.*
'Yes, he did.'

This CS update differs from the update by *Did Max arrive or not?*, cf. (34)(c): It does not involve any commitment by addressee or speaker, and it does not expect particular continuations, reflecting that such questions do not ask for an answer. But they store a record in an interest in an answer, by the multiple root.

12 Forms like *Whether Max arrived?* are not used in current English, but see Berkeley's *Querist* pamphlets (1735-37), which contain such questions, e. g. *Whether a Foreigner could imagine, that one half of the People were starving, in a Country which sent out such Plenty of Provisions?*.

Any development that introduces one of the proposition, e. g. by s_2 declaring commitment to φ, reduces the root, indicating that an information need of the CS is satisfied, cf. (62)(b).

The analysis of *ob*-questions without commitment phrases is supported as modifiers that are characteristic for ComPs like *ungelogen* 'without lying', *im Ernst* 'seriously' are problematic, cf. *ob Max *ungelogen / ?im Ernst angekommen ist?*. But deliberative polar questions often contain *wohl*, a discourse particle. Following the recent analysis by Eckardt (2020), *wohl* is a marker of defeasible inference. Assuming that x $|\sim_{w,t}$ p stands for 'x considers p true in w at t under circumstances that x considers stereotypical in w at t', with *wohl* a JP operator outside of the TP, we can analyze *wohl* with assertions as in (63). It enriches the input CS with the commitment by s_1 that s_1 considers it true in w at t that Max arrived, under stereotypical circumstances in w at t.

(63) $[\![[_{\text{ActP}}\ \textit{Max}_1\ [_{\text{Act}'}\ [_{\text{Act}^\circ}\ \textit{ist}_0\ \bullet]\ [_{\text{ComP}}\ \vdash\ [_{\text{JP}}\ [_{\text{J}'}\ \textit{wohl}\ [_{\text{J}'}\ [_{\text{J}^\circ}\ \text{J-}]$
$[_{\text{TP}}\ \text{t}_1\ \textit{angekommen}\ \text{t}_0]]]]]]]]]\!]^{s,a,t}$
$= \lambda C\ \{c \in C \mid c \subseteq \lambda w\ [s \vdash_{w,t} \lambda w\ [s\ |\sim_{w,t} \varphi_t]]\}$

To extend this analysis of *wohl* to deliberative *ob* questions we have to assume that a CP can host a judge phrase, and that the judge parameter can be fixed by speaker and addressee, as in (64). This generates a two-rooted output CS, where in one branch s+a can defeasibly infer φ_t, but not in the other one. Information that amounts to φ_t, or to $\neg\varphi_t$, will lead to a root reduction of this multiply rooted CS.

(64) $[\![[_{\text{CP}}\ \textit{ob}\ [_{\text{JP}}\ \textit{Max}_1\ [_{\text{J}'}\ \textit{wohl}\ [_{\text{J}'}\ [_{\text{J}^\circ}\ \text{J-}]\ [_{\text{TP}}\ \text{t}_1\ \textit{angekommen ist}]]]]\ \text{H\%}]\!]^{s,a,t}$
$= \lambda C\ [\{c \in C \mid c \subseteq \lambda w[s+a\ |\sim_{w,t} \varphi_t]\} \cup \{\ c \in C \mid c \subseteq \neg\lambda w\ [s+a\ |\sim_{w,t} \varphi_t]\}]$

Deliberative questions can also be formed with constitutent questions, in which case the presence of *wohl* is obligatory. We can assume the following analyis, assuming that Max and Sue are the only alternatives, Max m and Sue s:

(65) $[\![[_{\text{CP}}\ \textit{wer}\ [_{\text{JP}}\ \text{t}_1\ [_{\text{J}'}\ \textit{wohl}\ [_{\text{J}'}\ [_{\text{J}^\circ}\ \text{J-}]\ [_{\text{TP}}\ \text{t}_1\ \textit{angekommen ist}]]]]\ \text{H\%}]\!]^{s,a,t}$
$= \lambda C\ [\{c \in C \mid c \subseteq \lambda w\ [s+a\ |\sim_{w,t} \varphi_t[m]]\} \cup \{\ c \in C \mid c \subseteq \lambda w\ [s+a\ |\sim_{w,t} \varphi_t[s]]\}]$

The output CS is a multiple-rooted CS (in the present case just a two-rooted CS) in which speaker and addressee either defeasibly infer that Max arrived, or defeasibly infer that Sue arrived. A later commitment that, e. g., Max arrived, will strengthen the option that Max arrived, and, by scalar implicature, eliminate the other options. In this analysis, we can identify a reason why *wohl* is obligatory in such constituent questions: Without it, the input CS would be enriched in a way that guarantees that one of the options (here that Max arrived, and that Sue arrived) is true. With *wohl*, which is time-indexed, the input is just restricted so that stereotypical knowledge indicates that one of the question options, e. g. that there is defeasible knowledge that Max arrived, or that Sue arrived, is given.

2.13 Conclusion

This article presented two extensions of the familiar notion of Common Ground. First, I have argued for the role of commitments in getting propositions into the CG. I argued for a separate syntactic projection, the ComP, with an operator $\vdash$ that expresses the commitment of a participant for a proposition. I proposed Commitment States to model CGs, which contain information about which participants are committed to which propositions. Second, I have argued that questions restrict the development of the CG, and I proposed the notion of Commitment Spaces (CS) as commitment states plus continuations.

This model differs from the account of Farkas & Bruce (2010) in two respects. First, in the model developed here, the commitments of participants for propositions remain in the CG; in the model of Farkas & Bruce (2010) they play only a role in the process of negotiation. Second, the notion of continuation is more comprehensive in Commitment Spaces; in Farkas & Bruce (2010) continuations play a role only in the negotiation phase, in form of a negotiating "table". The current model differs also from traditional question semantics, including Inquisitive Semantics, as it allows for monopolar questions.

I have shown how a range of question types – polar questions, polar questions with propositional negation, polar questions with high negation, alternative questions and constituent questions – can be handled in the Commitment Space framework. For question tags, not treated here, see Krifka (2015); for focus and topic in questions, see Kamali & Krifka (2020). I have also discussed the relation between embedded questions and root questions, arguing that they are derived in parallel.

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