Propositional discourse referents and anaphora in dialogue[1]

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Abstract. The article develops the notion of propositional discourse referents that contain dependent discourse referents. It explains the enablement of anaphora on the confirming uptake of assertions and questions by *yes*, and the blocking of anaphora by *no*, as well as the role of propositional anaphora like *so*. The explanation is embedded in a version of dynamic semantics that is based on dynamic context sets with their continuations.

Keywords discourse referent, negation, dynamic interpretation, assertion, question, dialogue, response particles

1 Introduction

It is well-known that negation blocks the accessibility of discourse referents (henceforward "drefs"). Karttunen (1969), who introduced the notion of drefs, pointed out that sequences like *Bill does not have a car. *It is black.* are ruled out when *it* is supposed to refer to the dref of *a car*. This was captured in formal models such as Heim (1983) and Kamp and Reyle (1994). We notice here that the rejection of an assertion in dialogue has the same effect, cf. (1).

(1) A: *Bill has a car.* B: a. *No. #It is black.* / b. *Yes. It is black.* .

Karttunen (1969) also showed that indefinites in polar questions do not reliably introduce drefs for later uptake, as in *Does John have a car? #It is a Mustang.* However, as he argued, this is not always the case: Conjoined questions like *Does John have a car and is it a Mustang?* are fine (cf. also van Rooy 1998, Groenendijk 1998, Enguehard 2021). And on having visual evidence that the addressee has written a letter, *Did you write a letter? Show it to me!* is fine as well. We notice here that after an affirming response, anaphoric uptake of the dref is possible:

(2) A: *Does Bill have a car?* B: a. *No. #It is black.* / b. *Yes. It is black.*

It has been noticed by various authors (Groenendijk 1998, van Rooy 1998, Haida 2008, Li 2020, Roelofsen and Dotlacil 2023) that wh-expressions introduce drefs, as in *What are you eating? It looks good.* However, this uptake also depends on a non-rejecting answer:

(3) A: *What did you eat?* B: a. *Nothing. #It was good.* / b. *A hamburger. It was good.*

Another phenomenon that also appears in monologic discourse is that drefs that are inaccessible otherwise can be accessed after propositional anaphors like *so*:

(4) *It is not clear whether Bill has a car. #It is black.* / *If so, it is black.*

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The observations concerning the availability of drefs in dialogues in (1) to (3), and after propositional anaphors like *so* in (4), are straightforward. However, they have not figured prominently in formal theories of discourse interpretation. Theories of propositional anaphora like, Snider (2017, 2019) and Meijer (2020), do not deal with drefs that are dependent on propositional drefs, and theories of drefs dependent on propositions and indices like, Stone (1999), Braseovanu (2010) and Hofmann (2022, 2025) do not deal with dialogues.

The present paper tries to amend this situation. One central idea is that response particles like *yes* and *no* and propositional anaphors like *so* pick up drefs anchored to a proposition that were introduced in the preceding conversation. These propositional drefs (henceforward "pdrefs") are anchored to propositions that come with their own drefs, and they can unlock them for further update. This requires a refinement of dynamic interpretation. The resulting approach can capture the role of propositional anaphora like *so* in monologic discourse as in (4), where they release drefs that would otherwise be inaccessible. The second central idea is that in dialogical discourse, the introduction of drefs is dependent on the confirmation or rejection of the participants. This requires a combination of dynamic interpretation and a model of common ground development that allows for the negotiation of updates.

2 A framework for dynamic interpretation

In this section we will develop a framework of dynamic interpretation with drefs that are anchored to propositions that come with dependent drefs. It is built on the framework of Rooth (1987), as this format combines the dependency of meanings on possible worlds, representing truth conditions, and on variable assignments, representing accessible drefs.

Let us assume a set I of world-time indices i, i′ etc. that are ordered by a temporal relation <, where i < i′ stands for 'i precedes i'' and < is a branching time relation. Basic expressions are interpreted by a function F depending on an evaluation index i; thus, if α is a basic expression, $F_i(\alpha)$ is the meaning of α at the index i. We furthermore assume assignments like g, h, k that are partial functions from natural numbers n to meanings, and write $g <_n h$ to convey that g equals h except that h also contains n in its domain. Instead of g(n), I will write "g_n" for compactness, instead of λgλhλi[…] etc. I will write λghi[…], and in functional application like R(x)(y) I will omit parentheses and write R(xy).

I illustrate the intended interpretation by examples. As for the syntactic representation, I assume that the clause *Mary ate a cookie* has the syntactic structure (5), leaving details aside.

(5) $[_{TP}\ [_{T'}\ [_{T^o}\ \text{PAST}^2]\ [_{vP}\ [_{DP}\ \textit{Mary}]_1\ [[_{VP}\ \textit{eat}\ [_{DP}\ \textit{a cookie}]^3]]]]]$

We employ the convention that superscripts and subscripts indicate new vs. given drefs. Drefs for names may be given in the input assignment, and may be accommodated. Interpretation is by a function ⟦…⟧ that maps an input assignments g to a function from an output assignments h to a function from indices i to some semantic object, e.g. a truth value. Applying ⟦…⟧ to (5), we get the result in (6). The input assignment g is required to assign the dref 1 to Mary. The output assignment h differs from g by the drefs 2 and 3, where h_2 is a world-time index before i, h_3 falls under the predicate *cookie* at h_2, and it holds that h_1 (= g_1) eats h_3 at the index h_2.

(6) $[\![(5)]\!] = \lambda ghi: g_1=F_i(\textit{Mary})\ [g<_{2,3}h \wedge h_2<i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{eat})(h_3h_1)]$

The dynamic meaning (6) is defined only if dref 1 is already in the domain of the input assignment g. This may be the case if Mary was talked about before, and 1 was introduced anchored to Mary. It may also require accommodation, as specified in (7a) and illustrated in (7b,c).

(7) a. If ⟦[…]⟧(ghi) is not defined because g does not contain drefs that ⟦[…]⟧ expects, and there is a unique minimal way of extending g to g′ such that ⟦[…]⟧(g′) is defined, then take ⟦[…]⟧(g′)(h)(i) as the result of this application instead.
b. ⟦(5b)⟧(ghi): undefined, hence accommodation:
c. ⟦(5b)⟧(g ∪ {⟨1, F_i(*Mary*)⟩})(h)(i),
= λghi [$g <_{1,2,3} h \wedge g_1 = F_i$(*Mary*) ∧ $h_2 < i \wedge F_{h_2}$(*cookie*)(h_3) ∧ F_{h_2}(*eat*)($h_3 g_1$)]

To see how anaphoric uptake of drefs works, consider the continuation *She liked it* in (8). The pronouns *she* and *it* do not introduce new drefs but pick up drefs that exist in the input assignment g already. As they do not contain descriptive information, their referents cannot be accommodated following (7a), as the uniqueness requirement is typically violated. We have analyzed past tense as anaphoric, picking up the index 2 of the preceding sentence (cf. Kamp and Reyle 1993). As all indices in (8a) are given, the output assignment h is identical to g.

(8) a [TP [T′ [T° PAST$_2$] [vP [DP *she*$_1$] [VP *like* [DP *it*$_3$]]]]]]
b. ⟦(8a)⟧ = λghi: $FEM_i(g_1) \wedge OBJ_i(g_3) \wedge g_2 < i$ [$g = h \wedge F_{h_2}$(*like*)($h_3 h_1$)]

The two meanings (6) and (8) can be composed by rule (9a) for dynamic conjunction. Hence (5b) followed by (8b) results in the meaning (9b). Recall that the first sentence introduces the presupposition that g_1 is anchored to Mary, which is to be accommodated if Mary was not talked about before. The presuppositions of the second sentence are satisfied, and we can write them as truth conditions; in order to remind us that they were introduced as presuppositions in the compositional construction of the text I keep writing them in smaller font.

(9) a. ⟦[[TP φ] [TP ψ]]⟧ = ⟦[TP φ]⟧ ; ⟦[TP ψ]⟧ = λghi∃k[⟦[TP φ]⟧(gki) ∧ ⟦[TP ψ]⟧(khi)]
b. ⟦[[TP *Mary*$_1$ *ate*^{2} *a cookie*^{3}.] [TP *She*$_1$ *liked*$_2$ *it*$_3$.]]⟧
= λghi∃k[⟦(5b)⟧(gki) ∧ ⟦(8b)⟧(khi)]
= λghi: $g_1 = F_i$(*Mary*) [$g <_{2,3} h \wedge h_2 < i \wedge F_{h_2}$(*cookie*)($h_3$) ∧ F_{h_2}(*eat*)($h_3 h_1$) ∧
$FEM_i(g_1) \wedge NONHUM_i(h_3) \wedge F_{h_2}$(*like*)($h_3 h_1$)]

The meaning of expressions like (5) and (8) can be derived in a compositional way. We illustrate this for (5). The first step illustrates the meaning of indefinite DPs that introduce a new dref, following rule (10′a) and resulting in our case in the derivation (10b,c).

(10) a. ⟦[DP α]^n⟧ = λghix∃k[$g <_n k \wedge k_n = x$ ∧ ⟦[DP α]⟧(khix)]
b. ⟦[DP *a cookie*]⟧ = λghix[$g = h \wedge F_i$(*cookie*)(x)]
c. ⟦[DP *a cookie*]^3⟧ = λghix∃k[$g <_3 k \wedge k_3 = x$ ∧ ⟦[DP *a cookie*]⟧(khix)]
= λghix[$g <_3 h \wedge h_3 = x \wedge F_i$(*cookie*)(x)]

The transitive verb *eat* is combined with the object as in (11). This is the rule for DPs that refer to entities; quantifiers would take the verbal predicate as an argument (see Rooth 1987).

(11) a. ⟦[V° *eat*]⟧ = λghiyx[$g = h \wedge F_i$(*eat*)(yx)]
b. ⟦[VP [V° *eat*] [DP *a cookie*]^3]⟧
= λghix∃y∃k[⟦[DP *a cookie*]^3⟧(gki)(y) ∧ ⟦[V° *eat*]⟧(gkiyx)]
= λghix[$g <_3 h \wedge F_i$(*cookie*)(h_3) ∧ F_i(*eat*)($h_3 x$)]

As discussed above, names are interpreted by given drefs as in (12a). This contains a condition on the input assignment and requires that the input assignment and the output assignment are identical. The result of the combination with the VP meaning is illustrated in (12b).

(12) a. $[\![[_{DP}\ \textit{Mary}]_1]\!] = \lambda ghix:\ g_1{=}x \wedge g_1{=}F_i(\textit{Mary})\ [g{=}h]$
b. $[\![[_{vP}\ [_{DP}\ \textit{Mary}]_1\ [_{VP}\ [_{V^o}\ \textit{eat}\ ]\ [_{DP}\ \textit{a cookie}]^3]]]\!]$
$= \lambda ghi\exists x\exists k[[\![[_{DP}\ \textit{Mary}]_1]\!](gki)(x) \wedge [\![[_{VP}\ [_{V^o}\ \textit{eat}\ ]\ [_{DP}\ \textit{a cookie}]^3]]\!](khi)(x)]$
$= \lambda ghi:\ g_1{=}F_i(\textit{Mary})\ [g{<_3}h \wedge F_i(\textit{cookie})(h_3) \wedge F_i(\textit{eat})(h_3g_1)]$

Application of the non-anaphoric past tense operator introduces a new dref that is anchored to a time before the index i. This dref is used as the index of interpretation for the vP in its scope:

(13) $[\![[_{TP}\ \text{PAST}^2\ [_{vP}\ [_{DP}\ \textit{Mary}]_1\ [_{VP}\ [_{V^o}\ \textit{eat}\ ]\ [_{DP}\ \textit{a cookie}]^3]]]]\!]$
$= [\![\text{PAST}^2]\!]([\![[_{vP}\ [_{DP}\ \textit{Mary}]_1\ [_{VP}\ [_{V^o}\ \textit{eat}\ ]\ [_{DP}\ \textit{a cookie}]^3]]]\!])$
$= \lambda ghi:\ g_1{=}F_i(\textit{Mary})\ [g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{eat})(h_3g_1)]$

The syntactic indices for drefs are just a helpful device for presentation. For novel expressions, we can assume that the next unassigned dref is used. Given expressions identify the dref that is anchored to the entity uniquely determined by the chosen description, including gender features. If there is more than one such dref, the distinction between salient and less salient drefs determines the likely choice (cf. Beaver 2004, Bittner 2012).

Negation is interpreted as illustrated in (14) for *Mary didn't eat a cookie.* It states that there is no extension k with the indicated property. Consequently, the drefs k_2 and k_3 are not available for anaphoric reference, picking up the dref 1 for *Mary* is possible, however.

(14) a. $[_{NegP}\ [[_{Neg^o}\ \text{NEG}]\ [_{TP}\ [[_{T^o}\ \text{PAST}^2]\ [_{vP}\ [\textit{Mary}]_1\ [_{VP}\ [_{V^o}\ \textit{eat}]\ [_{DP}\ \textit{cookie}]^3]]]]]$
b. $[\![\text{NEG}]\!] = N = \lambda p\lambda ghi[g{=}h \wedge \neg\exists k[p(gki)]]$
c. $[\![[\text{NEG}\ [_{TP}\ \text{PAST}^2\ [_{vP}\ [_{DP}\ \textit{Mary}]_1\ [_{VP}\ \textit{eat}\ [_{DP}\ \textit{a cookie}]^3]]]]]\!]$
$= [\![\text{NEG}]\!]([\![[_{TP}\ \text{PAST}^2\ [_{vP}\ [_{DP}\ \textit{Mary}]_1\ [_{VP}\ \textit{eat}\ [_{DP}\ \textit{a cookie}]^3]]]]\!])$
$= \lambda ghi:\ g_1{=}F_i(\textit{Mary})[g{=}h \wedge \neg\exists k[g{<_{2,3}}k \wedge k_2{<}i \wedge F_{k2}(\textit{cookie})(k_3) \wedge F_{k2}(\textit{eat})(h_3g_1)]]$

In the current section we have developed the details of a framework of dynamic interpretation that can capture anaphoric uptake of drefs and the blocking of uptake by intervening negation. In the next section we will see that this framework also allows us to model pdrefs.

3 Dynamic propositional discourse referents and propositional anaphors

Propositional discourse referents were suggested by Krifka (2013) for the analysis of response particles such as *no* and *yes*. With an assertion or a polar question, the speaker introduces a pdref for a TP, which the addressee can pick up and assert as well (with *yes*) or assert its negation (with *no*), cf. (15a). Krifka (2013) is mostly interested in cases in which the antecedent TP is negated, arguing that in this case, the antecedent clause introduces two pdrefs, one being the negation of the other. This leads to ambiguities of the response particles *yes* and *no*, cf. (15b).

(15) a. A: [ASS [$_{TP}$ *Mary ate a cookie*]]. B: *Yes.* / B: *No.*
↳ φ ASS(φ) ASS(¬φ)
b. A: [ASS [$_{NegP}$ *Mary didn't* [$_{TP}$ _ _ *eat a c.*]]. B: *Yes.* / B: *No.*
↳$\overline{\varphi}$ (= ¬φ) ↳φ ASS($\overline{\varphi}$), ASS(φ) ASS(¬$\overline{\varphi}$), ASS(¬φ)

The notion of pdref was worked out more formally in Snider (2017, 2019). But neither Krifka nor Snider give a formal account that would capture the restrictions for anaphoric uptake as in (1) and (2). One way of dealing with dynamic pdrefs is the one specified in (16a) and illustrated in (16b): The TP, as the syntactic category that is interpreted as proposition, introduces a pdref.

(16) a. $[\![[_{TP}\ \ldots]^n]\!] = \lambda ghi\ [g <_n h \wedge g_n = [\![[_{TP}\ \ldots]]\!]]$
b. $[\![[_{TP}\ \text{PAST}^2\ [_{vP}\ [_{DP}\ \textit{Mary}]_1\ [_{VP}\ [_{V^o}\ \textit{eat}\ ]\ [_{DP}\ \textit{a cookie}]^3]]]^4]\!] = \lambda ghi:\ [g <_4 h \wedge h_4 = (13)]$

Note that (16b) introduces just the pdref 4 for the proposition that Mary ate a cookie, but not the drefs 2 and 3 for a cookie and an index at which an eating happened. The "piggyback" drefs 2 and 3 can be recovered by rule (17a). As (17b) shows, this interpretation "releases" the drefs 2 and 3 that were "wrapped into" the pdref 4.

(17) a. If n is a pdref: $[\![n]\!] = \lambda ghi[g_n(ghi)]$
b. $[\![4]\!] = \lambda ghi[g_4(ghi)]$, = (13)

The interpretation rule (16a) is problematic when trying to model cases like (15b), as the pdref φ introduced on the TP would be trapped by negation. We may follow Snider (2017, 2019), who proposed that negation introduces the pdref for the proposition it scopes over. Here I assume that the pdref is introduced by presupposition, which escapes the scope of negation. This allows for modelling the accessibility of pdrefs under negotiations in dialogue. In particular, I assume interpretation rule (18a), illustrated in (18b); the presupposed dref 1 is projected.

(18) a. $[\![[_{TP}\ \ldots]_n]\!] = \lambda ghi:\ g_n = [\![[_{TP}\ \ldots]]\!]\ [[\![n]\!](ghi)]$
b. $[\![[_{TP}\ \text{PAST}^2\ [_{vP}\ [_{DP}\ \textit{Mary}]_1\ [_{VP}\ [_{V^o}\ \textit{eat}\ ]\ [_{DP}\ \textit{a cookie}]^3]]]_4]\!]$
$= \lambda ghi:\ g_4 = (13)\ [[\![4]\!](ghi)]$
$= \lambda ghi:\ g_1 = F_i(\textit{Mary}),\ g_4 = \lambda ghi[g <_{2,3} h \wedge h_2 < i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{eat})(h_3 g_1)]$
$[g <_{2,3} h \wedge h_2 < i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{eat})(h_3 g_1)]$

The resulting formula presupposes that g contains indices 1 and 4 anchored to Mary and the dynamic proposition that Mary (=1) ate a cookie, and it changes g to h by introducing the drefs 2 and 3 for a time in the past and a cookie such that Mary ate the cookie at this time. If the input g does not contain the index, it can be accommodated, following rule (7a).

Let us consider the case of negation, (14c). Applied to (18b), it results in (19), where the presuppositions of (18b) projects to the input assignment.

(19) $[\![[\text{NEG}\ [_{TP}\ \text{PAST}^2\ \textit{Mary}_1\ \textit{eat}\ [\textit{a cookie}]^3]_4]]\!]$
$= [\![\text{NEG}]\!]([\![[_{TP}\ \text{PAST}^2\ \textit{Mary}_1\ \textit{eat}\ [\textit{a cookie}]^3]_4]\!])$
$= \lambda ghi:\ g_1 = F_i(\textit{Mary}),\ g_4 = \lambda ghi[g <_{2,3} h \wedge h_2 < i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{eat})(h_3 g_1)]$
$[g = h \wedge \neg \exists k[g <_{2,3} k \wedge k_2 < i \wedge F_{k2}(\textit{cookie})(k_3) \wedge F_{k2}(\textit{eat})(k_3 g_1)]$

The projection rule guarantees that the pdref 4 is accessible outside of the scope of negation. Now we can model access to this pdref by propositional anaphora as in (20a,b):

(20) a. *Mary did not eat a cookie but Bill thinks so*.
b. *Mary did not eat a cookie, and Bill thinks so, too.*

Let us assume (21a) for interpretation of the second clause of (20a), disregarding *but*. The interpretation of *think* is sketched in (21b), and the combination of the two sentences is given

in (21c). Notice that the pdref 4 of the first clause is projected to the input assignment g, and is accessible for the second clause. The drefs 2 and 3, on the other hand, are not accessible.

(21) a. $[\![[_{TP}\ \text{PRES}\ [_{vP}\ [\text{Bill}]_5\ [_{VP}\ \textit{thinks}\ [_{TP}\ \textit{so}]_4]]]]\!] = \lambda ghi:\ g_5{=}F_i(\textit{Bill})\ [g{=}h \wedge F_i(\textit{think})(g_4g_5)]$

b. $F_i(\textit{think})(g)(p)(x)$ is true if x thinks in i that there is an h such that p(ghi) is true, i.e. if $\forall i'[i'$ is doxastically accessible to x at i $\rightarrow \exists h[p(ghi')]]$

c. $[\![[_{TP}\ \textit{Mary}_1\ \textit{did}_2\ \textit{not}\ [_{TP}\ \text{PAST}^2\ \_\ \_\ \textit{eat a cookie}^3]_4]\ [\textit{(but) Bill}_5\ \textit{thinks so}_4]]\!]$
= (19) ; (21a)
$= \lambda ghi:\ g_1{=}F_{h_2}(\textit{Mary}),\ g_4{=}\lambda ghi[g{<_{2,3}}h \wedge h_2{<}i \wedge F(h_2)(\textit{cookie})(h_3) \wedge F(h_2)(\textit{eat})(h_3g_1)],\ g_5{=}F_i(\textit{Bill})$
$[g{=}h \wedge \neg\exists k[[\![4]\!](gki)] \wedge F_i(\textit{think})(h_4h_5)]$

For the continuation in (20b), we assume that a pdref is introduced at the level of the negated clause as well, which is then picked up by *so* in the second clause:

(22) a. $[\![[_{TP}\ \textit{Mary}_1\ \textit{did}_2\ \textit{not}\ [_{TP}\ \text{PAST}^2\ \_\ \_\ \textit{eat a cookie}^3]_4]_5]\!]$
$= \lambda ghi:\ g_1{=}F_i(\textit{Mary}),\ g_4{=}\lambda ghi[g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{eat})(h_3g_1)],$
$g_5{=}\lambda g\lambda h\lambda i[g{=}h \wedge \neg\exists k[g{<_{2,3}}k \wedge k_2{<}i \wedge F_{k2}(\textit{cookie})(k_3) \wedge F_{k2}(\textit{eat})(k_3g_1)]$
$[g{=}h \wedge \neg\exists k[g{<_{2,3}}k \wedge k_2{<}i \wedge F_{k2}(\textit{cookie})(k_3) \wedge F_{k2}(\textit{eat})(k_3g_1)]$

b. $[\![[_{TP}\ \text{PRES}\ [_{vP}\ [\text{Bill}]_6\ [_{VP}\ \textit{thinks}\ [_{TP}\ \textit{so}]_5]]]]\!] = \lambda ghi:\ g_6{=}F_i(\textit{Bill})\ [g{=}h \wedge F_i(\textit{think})(g_5g_6)]$

c. $[\![[_{TP}\ \textit{Mary}_1\ \textit{did}_2\ \textit{not}\ [_{TP}\ \text{PAST}^2\ \_\ \_\ \textit{eat a cookie}^3]_4]_5\ [_{TP}\ \text{PRES Bill}_6\ \textit{thinks so}_5]]\!]$
= (22a) ; (22b)
$= \lambda ghi:\ g_1{=}F_i(\textit{Mary}),\ g_6{=}F_i(\textit{Bill}),\ g_4{=}\lambda ghi[g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{eat})(h_3g_1)],$
$g_5{=}\lambda g\lambda h\lambda i[g{=}h \wedge \neg\exists k[g{<_{2,3}}k \wedge k_2{<}i \wedge F_{k2}(\textit{cookie})(k_3) \wedge F_{k2}(\textit{eat})(k_3g_1)]$
$[g{=}h \wedge \neg\exists k[[\![4]\!](gki)] \wedge F_i(\textit{think})(h_5h_6)]$

In this section, we have achieved a modelling of drefs for dynamic propositions. Such pdrefs are anchored to dynamic propositions that contain their own drefs, which do not automatically become accessible. The second crucial assumption is that pdrefs project as presuppositions and can be accessed later in discourse, even when they were introduced in the domain of negation.

4 Context sets and their update

Our next task is to introduce a notion of update that allows for negotiations between the interlocutors, as in (1) and (2). We will employ a model of conversation that consists in the incremental change of the common ground (henceforward, "CG"). The CG is the information that is supposed to be shared by the participants of a conversation at a particular point; it is the background at which a communicative act is performed, and it is changed by that very act.

The classical model CGs is based on context sets, sets of world-time indices (Stalnaker 1978, 2002). To integrate anaphoric reference, we assume context sets with drefs (cdrefs), modelled as sets of pairs of indices and assignments, where all assignments have the same domain. Update of a cdref c with a dynamic proposition p is defined in (23a,b) and illustrated in (23c).

(23) a. $c + p = \{\langle i,h\rangle \mid \forall gi[\langle i,g\rangle{\in}c \rightarrow \langle i,g\rangle \text{ defined for p}] \wedge \exists g[\langle i,g\rangle{\in}c \wedge p(ghi)]\}$

b. $\langle i,g\rangle$ definied for p iff $\exists h[p(ghi)] \vee \neg\exists h[p(ghi)]$

c. $c + [\![[_{TP}\ [_{T'}\ [_{T^0}\ \text{PAST}^2]\ [_{vP}\ [_{DP}\ \textit{Mary}]_1\ [[_{VP}\ \textit{eat}\ [_{DP}\ \textit{a cookie}]^3]]]]]\!]$
$= c + (13) = \{\langle i,h\rangle \mid \exists g[\langle i,g\rangle{\in}c \wedge g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{eat})(h_3g_1)]\},$
provided that $\forall\langle i,g\rangle{\in}c$: $g_1{=}F_i(\textit{Mary})$

The definition ensures that presuppositions of p become presuppositions of the cdref c. If they are not satisfied in c they can be accommodated minimally to c′ such that the update is satisfied. This accommodation is "cheap" in the sense that it extends each of the assignments in c in a unique way, cf. discussion around (7) above.

(24) If presupposition is not satisfied, accommodate with presupposition first, then update:
a. $c + \lambda ghi\ [\langle i,g\rangle \in c \wedge g <_1 h \wedge h_1 = F_i(\textit{Mary})] = c^*$
b. $c^* + [\![[_{TP}\ [_{T'}\ [_{T^o}\ PAST^2]\ [_{vP}\ [_{DP}\ \textit{Mary}]_1\ [[_{VP}\ \textit{eat}\ [_{DP}\ \textit{a cookie}]^3]]]]]]\!] = c'$

Discourse anaphora can be dealt with in a straightforward way. For example, further update of c′ computed in (24b) by the dynamic proposition (8) results in (25):

(25) $c' + [\![[_{TP}\ [_{T'}\ [_{T^o}\ PAST_2]\ [_{vP}\ [_{DP}\ \textit{she}_1]\ [_{VP}\ \textit{like}\ [_{DP}\ \textit{it}_3]]]]]]]\!]$
$= c' + \lambda ghi:\ FEM_i(g_1) \wedge NONHUM_i(g_3) \wedge g_2 <_i [g=h \wedge F_{h_2}(\textit{like})(h_3 h_1)]$
$= \{\langle i,h\rangle \mid \exists g[\langle i,g\rangle \in c' \wedge [g=h \wedge h_2 <_i \wedge F_{h_2}(\textit{like})(h_3 h_1)]\}$,
provided that $\forall \langle i,g\rangle \in c'$: $[FEM_i(g_1) \wedge NONHUM(i)(g_3) \wedge g_2 <_i]$
$= \{\langle i,h\rangle \mid \exists g[\langle i,g\rangle \in c \wedge g <_{2,3} h \wedge h_2 <_i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{eat})(h_3 g_1) \wedge F_{h_2}(\textit{like})(h_3 h_1)]\}$
provided that $\forall \langle i,g\rangle \in c$: $g_1 = F_i(\textit{Mary}) = c''$

Taken together, (23) and (25) change the input cdref c to c″ by increasing the domain of the assignments by 2 and 3, provided that 1 is anchored to Mary (or can be so accommodated). In particular, 2 is anchored to a time before the index i, and 3 is anchored to a cookie, and it holds that the anchor of 1 eats the anchor of 3, and the anchor of 1 likes the anchor of 3 at the index that 2 is anchored to. We skipped in the final representation in (25) the presuppositions of the second clause, as they were satisfied by the prior application of the first clause.

5 A framework for negotiating updates

The update of cdrefs by a rule like (23) is still insufficient, as the introduction of drefs only holds when the addressee does not disagree with the speaker, cf. (1). This is obvious in the informal discussion of Stalnaker (1978, 2002), and there were attempts of formalizing these aspects in work starting from Hamblin (1971) and including Merin (1994) and Lauer (2013).

One framework is the table model of Farkas and Bruce (2010), see e.g. Roelofsen and Farkas (2015), Malamud and Stephenson (2015), Rudin (2018) and others. It has, beside a representation of the CG, a negotiation table. When a speaker S wants to update the CG with a proposition p, S first commits to p by putting it on the table. It depends on the reaction of the addressee A whether p enters the CG: If A commits to p as well, then p is admitted, and the commitments of the interlocutors are taken off the table. If A commits to ¬p, then p is not admitted, and again the commitments are taken off the table. With polar questions, S puts both p and ¬p on the table and expects that the addressee commits to either p or ¬p; this then enters the CG, and the commitment is taken off the table. – I see two problems with this approach: First, it does not provide for a way that the A just goes along with an assertion, e.g. by saying *okay*, or not saying anything at all. In this case, p enters the CG but A does not become responsible for it. Secondly, the table model does not keep a record of which participant is committed to which proposition. But this is relevant for the progression of discourse; for example, a speaker who has committed to a proposition can later retract that proposition.

For these reasons, we will follow here the Commitment Space framework developed in Cohen and Krifka (2014), Krifka (2015) and subsequent work. In this model, CGs not only contain the information assumed to be shared but also the possible continuation of this information. For example, in a question, the speaker does not add factual information but restricts the way how the CG should continue – namely, by an answer to the question (cf. the notion of inquisitive meanings in Ciardelli et al. 2019). In Krifka (2015), this framework was used in combination with a backtracking algorithm that is extraneous to the representation of the CG itself. In Krifka (2022), I made use of the continuations inherent in the Commitment Space framework to deal with negotiations by including various reactions of the participants in those continuations. The current article is an elaboration of this model, taking account of the anaphoric choices that we have discussed with examples like (1) and (2).

What are continuations? We define that the cdref c′ is a possible continuation of c as in (26).

(26) Continuation of cdrefs: $c \preccurlyeq c'$ iff $\forall i'h[\langle i',h\rangle \in c' \rightarrow \exists ig[\langle i,g\rangle \in c \wedge i \leq i' \wedge g \leq h]]$

Commitment spaces C are defined as sets of cdrefs. Proper commitment spaces contain a smallest cdref, the root √C, as defined in (27). It stands for the information shared by the interlocutors (but note that Kamali and Krifka 2020 allow for multiple roots to model contrastive topics).

(27) $\surd C = \iota c\ [c \in C \wedge \forall c'[c' \in C \rightarrow c \preccurlyeq c']]$

Commitment spaces can be updated. As argued for in Krifka (2024a,b), we have to distinguish between two types of updates: "Informative" updates that restrict the indices in a context set, and "performative" updates that change the indices of the context set (cf. also Szabolcsi 1982). Informative update is defined in (28), based on the definition of cdref update (16a).

(28) Informative update: $\circ p = \lambda C\ \{c \in C \mid \surd C + p \preccurlyeq c\}$, writing $C + \circ p$ for $\circ p(C)$

In contrast, performative updates can also change the indices. It is based on the update of indices as defined in (29a), and defined in (29b).

(29) Performative update:
a. $[\langle i,g\rangle + p] = \{\langle i',h\rangle \mid \forall i''[i'' < i \leftrightarrow i'' < i'$, i.e. i and i′ have the same history, p(g)(h)(i′), and i and i′ do not differ in any other relevant way$\}$
b. $\bullet p = \lambda C\ \{c \in C \mid \surd C + p \preccurlyeq c\}$, writing $C + \bullet p$ for $\bullet p(C)$

We can define certain operations on updates U, U′ of commitment spaces, as in (30), that will play a role in the modelling of aspects of negotiation.

(30) a. $[U\ ;\ U'] = \lambda C[U'(U(C))]$ dynamic conjunction
b. $[U\ \mathrm{V}\ U'] = \lambda C[U(C) \cup U'(C)]$ disjunction
c. $[-U](C) = \lambda C\{c \in C \mid \neg\exists c'[c \preccurlyeq c' \wedge c' \in [U(C) - \{\surd C\}]\}$ negation

Dynamic conjunction simply composes two updates. Disjunction forms the union of two updates of an input C. This is not necessarily a proper commitment space as it may not have a unique root. The most complex operation is negation (it differs from denegation defined in Krifka 2015 as $\sim U = \lambda C[C - U(C)]$). It identifies those cdrefs c in C that cannot develop into cdrefs c′ that belong to the update U(C), except of the root of C itself. We will see this rule

operative in the analysis of questions in Section 8. Update with the negation of an update does not necessarily result in a proper commitment space.

6 Update with commitments

In this section we will show how the framework presented in Section 5 can be used to model the negotiation of CG update. From now on it will be crucial to refer to the participants of the conversation – the speaker and the addressee, which I suppressed so far to make the exposition easier. They also play a role for the interpretation of personal pronouns like *I* and *you*, of course. Instead of meanings of the form λghi[…], we now assume meanings of the form λsaghi[…], where s and a are the arguments for the speaker and addressee. Alternatively, s and a could be values of a situation argument for which values like speaker and addressee are defined (cf. contexts in Kaplan 1979 and Lewis 1980). For illustration, we assume representations as in (31a); the compositional update rules would have to be redefined for this format.

(31) a. $[\![[_{TP}\ \text{PAST}^2\ \textit{Mary}_1\ \textit{give you}\ [\textit{a cookie}]^3]]\!]$
$= \lambda\text{saghi: } g_1=F_i(\text{Mary})\ [g<_{2,3}h \wedge h_2<i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3ah_1)]$
b. $[\![[_{TP}\ \ldots]_n]\!] = \lambda\text{saghi: } g_n=[\![[_{TP}\ \ldots]]\!](sa)\ [[\![n]\!](ghi)]$
c. $[\![[_{TP}\ \text{PAST}^2\ \textit{Mary}_1\ \textit{give you}\ [\textit{a cookie}]^3]_4]\!]$
$= \lambda\text{saghi } g_1=F_i(\textit{Mary}),\ g_4=\lambda ghi[g<_{2,3}h \wedge h_2<i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3ah_1)][[\![4]\!](ghi)]$

The rule for indexing a TP is given in (31b), which ensures that the pdref is interpreted with respect to the current speaker and addressee. This is exemplified in (31c), using reference to the pdref 4 in the description of the body of the function for a more compact representation.

Let us now consider assertions. Under the commitment theory of assertion (cf. MacFarlane 2011, Geurts 2019, Shapiro 2020), the speaker vouches for the truth of a proposition p, which is a guarantee for the addressee to assume p as well, and to accept p into the CG. I write "x⊢p" for the proposition 'x vouches for the truth of p' and assume that this proposition is reflected in a "Commitment Phrase" ComP (cf. Krifka 2015). ComPs are analyzed as in (32a).

(32) a. $[\![[_{ComP} \vdash [_{TP}\ldots]]]\!] = \lambda\text{saxghi}[g=h \wedge x\vdash_{i,g} [\![[_{TP}\ldots]]\!](sa)]$,
where $x\vdash_{i,g} p$ stands for: x vouches in i for there being an h such that p(ghi) is true
b. $[\![[_{ComP} \vdash [_{TP}\ \text{PAST}^2\ \textit{Mary}_1\ \textit{give you}\ [\textit{a cookie}]^3]_4]\!]$
$= \lambda\text{saxghi}[x\vdash_{i,g} (31a)(sa)]$
$= \lambda\text{saxghi:} g_1=F_i(\textit{Mary}),\ g_4=\lambda ghi[g<_{2,3}h \wedge h_2<i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3ah_1)][g=h \wedge x\vdash_{i,g} [\![4]\!]]$

The rule is exemplified in (32b). This presupposes for the input assignment g that the dref 1 is anchored to Mary and the dref 4 to the dynamic proposition that Mary gave the addressee a cookie (which contains drefs 2 and 3). The body states that x, which appears on the argument list, vouches for the truth of the dynamic proposition that Mary gave the addressee a cookie. It also states that the input assignment g is not changed (g=h), hence no binding options are introduced at this level; hence the drefs 2 and 3 cannot be accessed yet in subsequent discourse. The value of x will be determined as the speaker in assertions, the addressee in questions, and it might also be shifted in embedded clauses. In Krifka (2023) I assume another layer between ComP and TP, the Judgement Phrase JP to model the mitigating role of epistemic and evidential modifiers, like *probably* and *apparently*; this is omitted here.

Dynamic meanings like (32b) can be used to update commitment spaces, following the performative update rule (29). In Krifka (2015, 2023) I proposed a separate syntactic layer, the ActPhrase, with a head that is interpreted as performative update as in (33a), and illustrated in (33b). The result is an illocutionary act: Given a speaker s, an addressee a and a committer x, the committer vouches for the truth of a proposition, i.e. changes the input index i so that x is committed to the truth of the TP proposition. In establishing a commitment, this speech act differs from other uses of declarative sentences, such as declarations (cf. Krifka 2024c).

(33) a. $[\![[_{ActP} \bullet [\ \ldots]]]\!] = \lambda sax \bullet [[\![[\ldots]]\!](sax)]$
b. $[\![[_{ActP} \bullet [_{ComP} \vdash [_{TP}\ PAST^2\ \textit{Mary}_1\ \textit{give you}\ [\textit{a cookie}]^3]_4]]]]\!] =$
$= \lambda sax\ [\bullet \lambda ghi{:}g_1{=}F_i(\textit{Mary}),g_4{=}\lambda ghi[g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3 a h_1)][g{=}h \wedge x \vdash_{i,g} [\![4]\!]]$

In Krifka (2015, 2023), the committer variable x was fixed to the speaker with ActPs that are headed by the operator •. In the next section, I propose that this is achieved by yet another layer, the Discourse Phrase DiscP, inspired by the "interactional spine" of Wiltschko (2021).

7 Modelling assertions with options for negotiation

The update (33b) does not yet embody the typical communicative use of assertion: With the commitment to a proposition, the speaker commits to it with the goal of it being accepted in the CG by the addressee. This goal is so prominent that the speaker expects the addressee to make any objection explicit (cf. the collaborative principle of Walker 1996). We have to model this typical communicative goal of assertions. But we also have to model that the addressee can object against accepting the proposition that the speaker commits to.

The commitment space framework can capture the full impact of an assertion as it contains possible future continuations. The two continuation in an assertion, after vouching for a proposition (33), are that the TP meaning, the anchor of the pdref n, is accepted or that the addressee objects to its acceptance (cf. Krifka 2022). Objection to a proposition is modelled as follows:

(34) $x \dashv_{i,g} p$ iff x objects in i against assuming an h such that p(ghi) is true.

To object against assuming a proposition is not the same as to vouch for the truth of its negation, $x \vdash_{i,g} N(p)$, where x vouches in i that there is no h such that p(ghi) is true (cf. (14b) for N). It is also different from negating a truth commitment, $\neg[x \vdash_{i,g} p]$, as this would still be compatible with x admitting p into the CG, without x being committed to it. The axiomatic relations between $\vdash$ and $\dashv$ are given in (35a-c); with the integrity constraint (35d) they restrict possible updates. Notice that while $x \vdash p \wedge x \vdash \neg p$ is ruled out by (35c), $x \dashv p \wedge x \dashv \neg p$ is possible.

(35) a. $\forall gix[[x \vdash_{i,g} p] \rightarrow \neg[x \dashv_{i,g} p]]$: vouching for p excludes objecting against p
b. $\forall gix[[x \vdash_{i,g} \neg p] \rightarrow [x \dashv_{i,g} p]]$: vouching for ¬p includes objecting against p
c. $\forall gix[[x \vdash_{i,g} p] \rightarrow \neg[x \vdash_{i,g} \neg p]]$: vouching for p excludes vouching for ¬p
d. $\forall cgix[\langle i,g\rangle \in c \rightarrow x \dashv_{i,g} p] \rightarrow \neg\exists ghi[\langle i,g\rangle \in c \wedge p(gki)]$, for proper cdrefs c:
presence of an objection against p in c excludes acceptance of p in c

Assertions involve a commitment of the speaker to a proposition and a suggested informative update with that proposition, provided that the addressee does not object to that proposition. We model them as DiscPs with an assertive head ASS:

(36) a. $[\![[_{\text{DiscP}}\ \text{ASS}_n\ [_{\text{ActP}}\ldots]]]\!](\text{sa}) = [\![[_{\text{ActP}}\ldots]]\!](\text{sa}\mathbf{s})$; $[\circ[\![\text{n}]\!]\ \text{V}\ \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{a} \dashv_{i,g} [\![\text{n}]\!]]]$

b. $[\![[_{\text{DiscP}}\ \text{ASS}_4\ [_{\text{ActP}}\ \bullet\ [_{\text{ComP}} \vdash [_{\text{TP}}\ \text{PAST}^2\ \textit{Mary}_1\ \textit{give you}\ [\textit{a cookie}]^3]_4]]]]\!](\text{sa})$
$= \bullet\lambda\text{ghi: } g_1{=}F_i(\textit{Mary}),\ g_4{=}\lambda\text{ghi}[[g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3 a h_1)]$
$[\text{g=h} \wedge \text{s}\vdash_{i,g} [\![4]\!]]$; $[\circ[\![4]\!]\ \text{V}\ \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{a} \dashv_{i,g} [\![4]\!]]$

The assertion operator ASS refers to the most salient pdref, n, which is anchored to the proposition that is to be asserted. The rule for the assertive update (36a) states that the input commitment space is first updated performatively with the commitment of the speaker s (replacing x) to the TP proposition that is accessed via the pdref n; the ensuing continuations are restricted to either the informative update with the content of the pdref n or with an objection by the addressee a against accepting that content. This is exemplified in (36b). I would like to make two comments on this interpretation rule of assertions.

First, the interpretation of rule is compositional, as ASS refers to the pdref of the TP. We could also give a completely compositional version by defining an operator that combines ASS, • and $\vdash$ and refers to the TP directly, as in $[\![[\text{ASS}\bullet\vdash\ [_{\text{TP}}\ \ldots]]]\!](\text{sa}) = \bullet\lambda\text{ghi}[\text{s}\vdash[\![[_{\text{TP}}\ldots]]\!](\text{sa})]$; $\circ[\![[_{\text{TP}}\ldots]]\!](\text{sa})\ \text{V}\ \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{a}\dashv_{i,g} [\![[_{\text{TP}}\ldots]]\!](\text{sa})]$.

Second, commitment $\vdash$ and objection $\dashv$ are relative to an index i. However, commitments and objections are typically persistent. For example, if $\text{x}\vdash_{i,g}\text{p}$ and $i<i'$, then normally $\text{x}\vdash_{i',g}\text{p}$. We assume that such commitments can be changed only by an explicit performative update by the committer x. For example, a speaker s that committed to p, introducing $\text{s}\vdash_{i,g}\text{p}$ into a cdref c, can revoke this by performative update $\text{c} + \bullet\lambda\text{ghi}[\text{g=h} \wedge \neg[\text{s}\vdash_{i,g}\text{p}]]$.

Let us consider the various reactions to assertions. We can understand the response particles *yes* and *no* as commitments of the pdref or its negation, cf. (37a,b). We can also model the contribution of objection, expressed by reactions like *I doubt it*, or *I don't think so*, cf. (37c), and of mere acceptance, expressed by *okay* as in (37d), as negation of non-acceptance.

(37) a. $[\![\textit{yes}_n]\!](\text{sa}) = \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{s}\vdash_{i,g} [\![\text{n}]\!]]$
b. $[\![\textit{no}_n]\!](\text{sa}) = \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{s}\vdash_{i,g} \neg[\![\text{n}]\!]]$
c. $\text{nonaccept}_n(\text{sa}) = \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{s} \dashv_{i,g} [\![\text{n}]\!]]$
d. $[\![\textit{okay}_n]\!](\text{sa}) = \bullet\lambda\text{ghi}[\text{g=h} \wedge \neg[\text{s} \dashv_{i,g} [\![\text{n}]\!]]]$

The function of these responses is to prune one of the two disjunctive continuations after an assertion, following the integrity constraints (35). This is illustrated in (38), where we assume A and B as the initial speaker and addressee, respectively.

(38) a. Let ① = (32b)(ABA)
$= \lambda\text{ghi: } g_1{=}F_i(\textit{Mary}),\ g_4{=}\lambda\text{ghi}[g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3 \text{Boh}_1)][\text{A}\vdash_{g,i} [\![4]\!]]$
b. Let $C_1 = C_0 + (36b)(\text{AB}) = C_0 + \bullet① + [\circ[\![4]\!]\ \text{V}\ \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{B}\dashv_{i,g} [\![4]\!]]$
c. $C_1 + [\![\textit{yes}_4]\!](\text{BA}) = C_0 + \bullet① + \circ[\![4]\!] + \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{B}\vdash_{i,g}[\![4]\!]]$
as $\text{B}\dashv_{i,g} [\![4]\!]$ is incompatible with $\text{B}\vdash_{i,g} [\![4]\!]$, following (35a)
d. $C_1 + [\![\textit{no}_4]\!](\text{BA}) = C_0 + \bullet① + \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{B}\dashv_{i,g}[\![4]\!]] + \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{B}\vdash_{i,g}\neg[\![4]\!]]$
as $[\![4]\!]$ and $\text{B}\vdash_{i,g}\neg[\![4]\!]$ are incompatible in context sets, following (35b,d)
e. $C_1 + [\![\textit{okay}_4]\!](\text{BA}) = C_0 + \bullet① + \circ[\![4]\!] + \bullet\lambda\text{ghi}[\text{g=h} \wedge \neg[\text{B}\dashv_{i,g}[\![4]\!]]]$
as $\text{B}\dashv_{i,g} [\![4]\!]$ and $\neg[\text{B}\dashv_{i,g} [\![4]\!]]$ is a contradiction
f. $C_1 + \text{nonaccept}_4(\text{BA}) = C_0 + \bullet① + \bullet\lambda\text{ghi}[\text{g=h} \wedge \text{B}\dashv_{i,g}[\![4]\!]]$,
as $[\![4]\!]$ and $\text{B}\vdash_{i,g}\neg[\![4]\!]$ are incompatible in context sets, following (35b,d)

Notice that after the response *yes* and the acceptance by *okay* in (38c,e), the commitment space is updated by the dynamic proposition of the pdref 4, $\circ[\![4]\!]$, which introduces the dref 2 and

dref 3 (dref 1 for Mary is presupposed). This is not the case after the rejection by *no* or by non-acceptance in (38d,f). In this way, we have modelled the basic phenomenon of the uptake of discourse referents after assertions, as illustrated in (1).

However, the representation of *yes* and *no* in (37a,b) is problematic, as the assigned meanings would settle the issue for good. even though it can be contested, as in A: *It's raining.* B: *No.* A: *Yes.* B: *No*, possibly ad infinitum. This is accounted for by the interpretation given in (39a,b). Here, *yes* and *no* are interpreted as assertions of a proposition or its negation, leaving room for objections by other participants.

(39) a. $[\![yes_n]\!](sa) = \bullet\lambda ghi[g{=}h \wedge s \vdash_{i,g} [\![n]\!]] ; [\circ[\![n]\!] \vee \bullet\lambda ghi[g{=}h \wedge a \dashv_{i,g} [\![n]\!]]]$
b. $[\![no_n]\!](sa) = \bullet\lambda ghi[g{=}h \wedge s \vdash_{i,g} N([\![n]\!])] ; [\circ N([\![n]\!]) \vee \bullet\lambda ghi[g{=}h \wedge a \dashv_{i,g} N([\![n]\!])]]$

8 Updates with polar questions

Polar questions can be understood as requests by the speaker that the addressee commits to a proposition, thus giving a reason to accept it in the CG. They do not change the root of the input Commitment Space C but restrict its continuations. The operator ? for this move is defined in (40a) and the interpretation of the corresponding ActP in (40b), illustrated in (40c).

(40) a. $?p = \lambda C[\{\surd C\} \cup C{+}\bullet p]$
b. $[\![[_{ActP}\ ?\ [\ \ldots]]]\!] = \lambda sax\ ?[[\![\ldots]\!](sax)]$
c. $[\![[_{ActP}\ ?\ did_{\ t}\ [_{ComP} \vdash [_{TP}\ PAST^2\ Mary_1\ t\ give\ you\ [a\ cookie]^3]_4]]]]]\!]$
$= \lambda sax[?\lambda ghi{:}g_1{=}F_i(Mary),\ g_4{=}\lambda ghi[g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(cookie)(h_3) \wedge F_{h_2}(give)(h_3ah_1)][g{=}h \wedge x \vdash_{i,g} [\![4]\!]]]$

The DiscP for questions selects an interrogative ActP and offers the addressee a choice to follow the suggested update or object against it. We define this as in (41a); it consists of the update with the (interrogative) ActP, where the committer x is interpreted as the addressee, disjoined with the negation of this update. This is illustrated in (41b).

(41) a. $[\![[_{DiscP}\ QU\ [_{ActP}\ \ldots]]]\!] = [\![[_{ActP}\ \ldots]]\!](sa\mathbf{a}) \vee -[\![[_{ActP}\ \ldots]]\!](sa\mathbf{a})$
b. $[\![[_{DiscP}\ [_{Disc^o}\ QU\ did_i]\ [_{ActP}\ ?\ [_{ComP} \vdash [_{TP}\ PAST^2\ Mary_1\ t\ give\ you\ [a\ cookie]^3]_4]]]]]\!](sa)$
$= ?\ \lambda ghi{:}g_1{=}F_i(Mary),\ g_4{=}\lambda ghi[g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(cookie)(h_3) \wedge F_{h_2}(give)(h_3ah_1)][g{=}h \wedge a \vdash_{i,g} [\![4]\!]]$
$\vee\ -?\lambda ghi{:}g_1{=}F_i(Mary),\ g_4{=}\lambda ghi[g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(cookie)(h_3) \wedge F_{h_2}(give)(h_3ah_1)][g{=}h \wedge a \vdash_{i,g} [\![4]\!]]$

The first disjunct of (41b) keeps the root intact and restricts the continuation to the addressee to commitments to the TP proposition that Mary gave the addressee a cookie. This is the disjunct that is compatible with an affirmative answer, like *yes*$_4$, picking up the pdref 4. The second disjunct of (41b) enables non-confirming reactions of the addressee, like *no*$_4$, that would lead to a contradiction with the first disjunct. Following the definition of update negation in (30d), the second disjunct is interpreted as follows (note that the part $-\{\surd C\}$ in the definition removes the root $\{\surd C\}$ that is introduced by the interpretation of ?):

(42) $-?\lambda ghi{:}\ g_1{=}F_i(Mary),\ g_4{=}\lambda ghi[g{<_{2,3}}h \wedge h_2{<}i \wedge F_{h_2}(cookie)(h_3) \wedge F_{h_2}(give)(h_3ah_1)][g{=}h \wedge a \vdash_{i,g} [\![4]\!]]$
$= \lambda C\ \{c{\in}C\ |\neg\exists c'[c \preccurlyeq c' \wedge c'{\in}[C + \bullet\lambda ghi{:}g_1{=}F_i(Mary),\ g_4{=}\lambda ghi[\ldots][g{=}h \wedge a \vdash_{i,g} [\![4]\!]]]]\}$

This is the set of cdrefs c in the input commitment space C that are **not** derived from cdrefs in the C updated with $a \vdash [\![4]\!]$. The update $a \vdash \neg[\![4]\!]$ can be performed for this disjunct.

To illustrate polar questions and possible responses, consider the following cases, where we assume again A and B as participants, and we use the meanings of *yes* and *no* as in (39).

(43) a. Let ② = (32b)(ABB)
= λghi: $g_1=F_i(Mary)$, g_4=λghi[$g<_{2,3}h \wedge h_2<i \wedge F_{h_2}(cookie)(h_3) \wedge F_{h_2}(give)(h_3 Boh_1)$][B⊢$_{g,i}$⟦4⟧]
b. Let C_1 = ⟦QU⟧(C_0) = C_0 + [?② V –?②]
c. C_1 + ⟦yes_4⟧(BA) =
C_0 + ?② + •λghi[g=h ∧ B⊢$_{i,g}$⟦4⟧] ; [∘⟦4⟧ V •λghi[g=h ∧ A⊣$_{i,g}$ ⟦4⟧]]
d. C_1 + ⟦no_4⟧(BA) =
C_0 + –?② + •λghi[g=h ∧ B⊢$_{i,g}$N(⟦4⟧)] ; [∘N(⟦4⟧) V •λghi[g=h ∧ A⊣$_{i,g}$ N(⟦4⟧)]]

The interpretations are a consequence of the incompatibility of yes_4 with ?② and of *no* with –?②. In the first case (if A does not object), the piggyback drefs 2 and 3 will get introduced into discourse due to the informative update ∘⟦4⟧. In the second case (again if A does not object) the drefs 2 and 3 will not be introduced. This explains Karttunen's observation in (2).

Our model predicts that the answer *okay* as defined in (37d) is infelicitous, as ¬[B⊣⟦4⟧] is compatible with either disjunct. It also enables us to model answers like *I don't know*. Without going into details, if a commitment [a⊢p] is established in a cdref, this should rule out the proposition that a does not know p in that commitment state, as these propositions are incompatible with normative rules of commitment (cf. Williamson 1997). Hence, *I don't know* is not compatible with the first disjunct, and has to be interpreted with respect to the second.

The second conjunct in (41b) could also be expressed by an objection, ?λghi: …[g=h ∧ a⊣$_{i,g}$ ⟦4⟧], as this also would be incompatible with the *yes* response and allow for responses like *no* or *I don't know*. This is because update with a⊣p has the same effect as the negation with the update a⊢p. We will see in the next section that the negation of update can be applied more widely. It could have als been used in the formulation of assertion in in (36a), by replacing •λghi[g=h ∧ a ⊣$_{i,g}$ ⟦n⟧] with –•λghi[g=h ∧ a ⊢$_{i,g}$ ⟦n⟧].

9 Updates with alternative questions

In the preceding section we proposed a sway to model simple polar questions. Notice that affirming answers *yes* and rejecting answers *no* were not treated on equal footing: The *yes* answer was interpreted with respect to the first disjunct, in which the speaker wants the addressee to commit to the proposition. The *no* answer, on the other hand, was interpreted with respect to the second disjunct, which can be considered as a fallback option if the addressee does not go along with what the speaker wants. This differs from classical treatments of such questions in the tradition of Hamblin (1973), which would model them as a pair of propositions, one being the negation of the other. In the current proposal for such questions, the proposition that corresponds to a *yes* answer has a more prominent role, and hence they are at least potentially biased towards the positive answer (for this reason, they were called "monopolar" in Krifka 2015, cf. also Biezma and Rawlins 2012 and Trinh 2014 for evidence for the asymmetric interpretation).

Alternative questions as in (44a) are different, as they propose both the proposition and its negation as possible continuations. In the current framework, we can treat them as disjunctions on the level of ActPs (cf. Krifka 2015) as in (44b), where negation, though realized as an adverb, has scope over the TP, and leads to the introduction of an additional pdref, cf. (14). This

results in the meaning (44c), a disjunction between two questions. As the ? operator preserves the root, this is a proper commitment space.

(44) a. *did Mary give you a cookie or ~~did she~~ not ~~give you a cookie~~*
b. $[_{ActP}\,[_{ActP}\,?\,\textit{did}_{\,t}\,[_{ComP}\vdash[_{TP}\,PAST^2\,\textit{Mary}_1\,t\,\textit{give you}\,[\textit{a cookie}]^3]_4]]]]$ *or*
$[_{ActP}\,[_{ActP}\,?\,\textit{did}_{\,t}\,[_{ComP}\vdash[_{NegP}\,[[_{Neg^0}\,NEG]\,[_{TP}\,PAST^2\,\textit{Mary}_1\,[t\,\textit{give you}\,[\textit{a cookie}]^3]_4]]]_5]]]]$
c. $[\![(44b)]\!] =$
$= \lambda sax[?\lambda ghi:\ g_1{=}F_i(\textit{Mary}),\ g_4{=}\lambda ghi[g<_{2,3}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3ah_1)][g{=}h \wedge x\vdash_{i,g}[\![4]\!]]\ V$
$?\lambda ghi:\ g_1{=}F_i(\textit{Mary}),\ g_4{=}\lambda ghi[g<_{2,3}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3ah_1)],$
$g_5{=}\lambda ghi[g{=}h \wedge \neg\exists k[g<_{2,3}k \wedge k_2{<}i \wedge F_{k_2}(\textit{cookie})(k_3) \wedge F_{k_2}(\textit{give})(k_3ak_1)]\ [g{=}h \wedge x\vdash_{i,g}[\![5]\!]]]$

The disjoined ActP can be a complement of QU, leading to the interpretation (45), with A as speaker and B as addressee.

(45) $[\![QU]\!]((44c))(AB) = (44c)(ABB)\ V\ {-}(44c)(ABB)$

The first disjunct restricts the continuations to commitments of B to the TP proposition or its negation, expressed by *She did* or *She didn't.* The affirmative answer is illustrated in (46). In case A does not object, the CG is updated by $\circ[\![4]\!]$, and the drefs 2 and 3 become available.

(46) $C + (45) + [\![[_{DiscP}\,ASS_4\,[_{ActP}\bullet[_{ComP}\vdash[_{TP}\,PAST^2\,\textit{Mary}_1\,\textit{give you}\,[\textit{a cookie}]^3]_4]]]]\!](BA)$
$= C + (44c)(ABB) + \bullet\lambda ghi:\ g_1{=}F_i(\textit{Mary}),\ g_4{=}\lambda ghi[[g<_{2,3}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3)$
$\wedge F_{h_2}(\textit{give})(h_3Boh_1)][g{=}h \wedge B\vdash_{i,g}[\![4]\!]]\ ;\ [\circ[\![4]\!]\ V\ \bullet\lambda ghi[g{=}h \wedge A\dashv_{i,g}[\![4]\!]]$
$= C + \bullet\lambda ghi:\ g_1{=}F_i(\textit{Mary}),\ g_4{=}\lambda ghi[[g<_{2,3}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3Boh_1)]$
$[g{=}h \wedge B\vdash_{i,g}[\![4]\!]]\ ;\ [\circ[\![4]\!]\ V\ \bullet\lambda ghi[g{=}h \wedge A\dashv_{i,g}[\![4]\!]]$

Answers *yes* and *no* are disfavored here because they have two candidate pdrefs to pick up, 4 and 5, which would lead to confusing results; if used, they preferably would pick up 4, which can be expected to be more salient as it is introduced by both disjuncts. The second disjunct in (45) allows replies by B that reject such continuations, as e.g. by *I don't know* or *I don't tell you*. The modelling correctly predicts that only the confirming answer, like *She did*$_4$, unpacks the piggyback drefs 2 and 3 for subsequent answers.

Alternative questions can be constructed with other alternatives than a proposition and its negation, as in example (47). Notice that the drefs for Mary and Sue in (47c) have to be distinct, as both are projected to the input assignment.

(47) a. *did Mary give you a cookie or ~~did~~ Sue ~~give you a cookie~~*
b. $[_{ActP}\,[_{ActP}\,?\,\textit{did}_{\,t}\,[_{ComP}\vdash[_{TP}\,PAST^2\,\textit{Mary}_1\,t\,\textit{give you}\,[\textit{a cookie}]^3]_4]]]]$ *or*
$[_{ActP}\,?\,\textit{did}_{\,t}\,[_{ComP}\vdash[_{TP}\,PAST^2\,\textit{Sue}_5\,t\,\textit{give you}\,[\textit{a cookie}]^3]_6]]]]$
c. $[\![(47b)]\!] =$
$= \lambda sax[?\lambda ghi:\ g_1{=}F_i(\textit{Mary}),\ g_4{=}\lambda ghi[g<_{2,3}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3ah_1)]\ [g{=}h \wedge x\vdash_{i,g}[\![4]\!]]$
$V\ ?\lambda ghi:\ g_5{=}F_i(\textit{Sue}),\ g_6{=}\lambda ghi[g<_{2,3}h \wedge h_2{<}i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{give})(h_3ah_1)]\ [g{=}h \wedge x\vdash_{i,g}[\![6]\!]]]$
d. $[\![QU]\!]((47c))(AB) = (47c)(ABB)\ V\ {-}(47c)(ABB)$

As an interrogative DiscP, with A as speaker and B as addressee, we get the result in (47d). The first disjunct limits the continuations to commitments of B that Mary gave B a cookie or that Sue gave B a cookie. If B asserts one of these options, then the piggyback drefs 2 and 3 for the index and the cookie are introduced, and can be taken up, as in *Sue, and she liked it.* The second disjunct-mallows for reactions like *I don't know* or *I don't tell you*, or *Neither of them gave me a cookie*.

Example (47) illustrated an alternative question with focus on a name, which we assumed to be presupposed. In (48) the alternatives are introduced by a non-presupposed item:

(48) a. *did Mary give you a cookie or ~~did Mary give you~~ a sandwich*
b. $[_{ActP}\,[_{ActP}$? *did* t $[_{ComP} \vdash [_{TP}$ PAST^2 *Mary*$_1$ t *give you* [*a cookie*]^3]$_4$]]]] *or*
$[_{ActP}$? *did* t $[_{ComP} \vdash [_{TP}$ PAST^2 *Mary*$_5$ t *give you* [*a sandwich*]^3]$_5$]]]]
c. ⟦(48b)⟧ =
= λsax?λghi: $g_1=F_i(Mary)$, $g_4=\lambda ghi[g<_{2,3}h \wedge h_2<i \wedge F_{h_2}(cookie)(h_3) \wedge F_{h_2}(give)(h_3ah_1)]$ $[g=h \wedge x \vdash_{i,g} ⟦4⟧]$ V
λsax?λghi: $g_1=F_i(Mary)$, $g_5=\lambda ghi[g<_{2,3}h \wedge h_2<i \wedge F_{h_2}(sandwich)(h_3) \wedge F_{h_2}(give)(h_3ah_1)]$ $[g=h \wedge x \vdash_{i,g} ⟦5⟧]$
d. ⟦QU⟧((48c))(AB) = (48c)(ABB) V –(48c)(ABB)

The dref on *a cookie* and *a sandwich* can be identical here, and would be under a dref-assigning algorithm due to the parallel structure. The first disjunct allows for answers like ~~*She gave me*~~ *a cookie*, which, when not challenged by A, introduces the drefs 2 and 3 into discourse. The second disjunct, again, allows for answers like *I don't know* or *She did not give me anything.*

10 Updates with constituent questions

Constituent questions are generalized alternative questions. *Who ate a cookie?* can be rephrased as *Did Mary eat a cookie, did Bill eat a cookie, or did Sue eat a cookie?* in case the relevant persons are Mary, Bill and Sue. This suggests an analysis in terms of a generalized disjunction over polar question meanings (cf. Krifka 2015), as illustrated in (49).

(49) a. *who gave you a cookie*
b. $[_{ActP}\,[who_t]\,[[_{Act^o}$? $]\,[_{ComP} \vdash [_{TP}$ PAST^2 t^1 *gave you* [*a cookie*]^3]$_4$]]]]
c. ⟦(49.b)⟧ = λsax $V_{y \in PERSON}$? λghi: $g_4=\lambda ghi[g<_{1,2,3}h \wedge h_1=y \wedge h_2<i \wedge F_{h_2}(cookie)(h_3) \wedge F_{h_2}(give)(h_3ah_1)]$
$[g=h \wedge x \vdash_{i,g} ⟦4⟧]$
d. ⟦QU⟧((49c))(AB) = (49c)(ABB) V –(49c)(ABB)

As illustrated in (49b,c), the wh-constituent moves to the specifier position of the ActP and is interpreted as a generalized disjunction over question meanings, here restricted to persons y. The wh trace is indexed with a new dref, here 1. After application of QU and specification of the speaker and addressee as A and B, we get the interpretation in (49d). The first disjunct restricts the continuations to commitments of B to propositions of the form 'y gave B a cookie', where y ranges over persons. A possible answer would be, *Mary gave me a cookie.* However, in order for this sentence to pick up a continuation of (49c) we have to assume that the name *Mary* introduces a new dref (note that it is accented as an answer to this wh-question). This is illustrated in (50); note that the answer, if not challenged by A, would release the piggyback drefs 1, 2, 3, thus explaining the observation in (3).

(50) C + (49d) + ⟦$[_{DiscP}$ ASS$_4$ $[_{ActP} \bullet [_{ComP} \vdash [_{TP}$ PAST^2 *Mary*^{1} *give you* t^3]$_4$]]]⟧(BA)
= C + (49c)(ABB) + •λghi: $g_4=\lambda ghi[[g<_{1,2,3}h \wedge h_2<i \wedge h_1=F_{h_2}(Mary) \wedge F_{h_2}(cookie)(h_3)$
$\wedge F_{h_2}(give)(h_3Boh_1)][g=h \wedge B \vdash_{i,g} ⟦4⟧]$; $[\circ ⟦4⟧$ V •λghi$[g=h \wedge A \dashv_{i,g} ⟦4⟧]$

I disregard here that the answer needs focus on *Mary*, see Kamali and Krifka (2020) for a modelling in terms of presuppositions on the input and the creation of exhaustivity implicatures, but without drefs. The second disjunct of (49d), again, allows for answers like *I don't know* or *Noone* ~~*gave me a cookie*~~.

We conclude this section with an example of an object constituent question:

(51) a. $[_{\text{ActP}}$ [*what*$_t$] $[[_{\text{Act}^o}$? *did*$_{t'}$] $[_{\text{ComP}} \vdash [_{\text{TP}}$ PAST^2 *Mary*$_1$ t′ *give you* [*a cookie*]$^3]_4]]]]$

b. $[\![(51a)]\!] = \lambda s a x\ V_{y \in \text{OBJECT}}$
? λghi: $g_1=F_i(\textit{Mary})$, $g_4=\lambda ghi[g<_{1,2,3}h \wedge h_3=y \wedge F_{h_2}(\textit{give})(h_3 a h_1)]$ $[g=h \wedge x \vdash_{i,g} [\![4]\!]]$

c. $[\![\text{QU}]\!]((51b))(AB) = (51b)(ABB)\ V\ -(51b)(ABB)$

11 Conjunctions of updates

In this last section we turn to conjoined clauses like conjoined questions observed by Karttunen (1969) that allow for anaphoric reference across clauses, as in the following examples:.

(52) a. *Mary bought a cookie and she ate it.*
b. *Did Mary buy a cookie, and did she eat it?*
c. *What did Mary buy, and did she eat it?*

Syntactic evidence shows that we do not have a conjunction on the level of TPs. but on the level of ActPs, if not DiscPs. This raises the problem that the second TP needs to access the drefs of the first one. This is possible, as the pdref of the first TP is projected and accessible at the point where the second TP is interpreted. This dependency can be made explicit, as in … *and if so, did she eat it* for (52b), but it is implicit in the examples (52). However, there is evidence for implicit anaphoric linking for the temporal interpretation (cf. Partee 1984, Kamp and Reyle 1993), and it is plausible to assume propositional linking as well. This is illustrated for (52b) interpreted as an ActP coordination, where the second TP refers to the pdref of the first TP as a background. Also, its PAST introduces a time following the time of the first TP.

(53) a. $[\![[_{\text{ActP}}$? *did*$_t$ $[_{\text{ComP}} \vdash [_{\text{TP}}$ PAST^2 *Mary*$_1$ t *buy* [*a cookie*]$^3]_4]]]\!]$
$= \lambda sax?\lambda ghi$: $g_1=F_i(\textit{Mary})$, $g_4=\lambda ghi[g<_{2,3}h \wedge h_2<i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{buy})(h_3 h_1)]$ $[g=h \wedge x \vdash_{i,g} [\![4]\!]]$

b. $[\![[_{\text{ActP}}$? *did*$_t$ $[_{\text{ComP}} \vdash [_{\text{TP}}$ 4 ; $[_{\text{TP}}$ PAST$_2{}^5$ *she*$_1$ t *eat it*$_3]_6]]]]\!]$
$= \lambda sax?\lambda ghi$: FEM($g_1$), INDEX($g_2$), OBJ($g_3$), PROP($g_4$), $g_6=\lambda ghi[g=h \wedge h_5<i \wedge h_2<h_5 \wedge F_{h_5}(\textit{eat})(h_3 h_1)]$
$[g=h \wedge x \vdash_{i,g} [[\![4]\!];[\![6]\!]]]$

c. (53a) ; (53b) $= \lambda sax?\lambda ghi$: $g_1=F_i(\textit{Mary})$, $g_4=\lambda ghi[g<_{2,3}h \wedge h_2<i \wedge F_{h_2}(\textit{cookie})(h_3) \wedge F_{h_2}(\textit{buy})(h_3 h_1)]$,
$g_6=\lambda ghi[g=h \wedge h_2<i \wedge h_2<h_5 \wedge F_{h_5}(\textit{eat})(h_3 h_1)]$ $[g=h \wedge x \vdash_{i,g} [\![4]\!] \wedge x \vdash_{i,g} [[\![4]\!] ; [\![6]\!]]]$

I have assumed in (53b) that the TP is interpreted with respect to an antecedent 4, which is available at the point where the second disjunct is interpreted. This works, however, the proposed mechanism has to be suitably constrained to the most salient pdref as antecedent.

12 Conclusion

We set out with the observation that the availability of discourse referents is constrained as to whether the propositions of the clauses in which they occur are agreed on by the participants. I have introduced the notion of propositional discourse referents that carry discourse referents with it, which become available only under certain conditons. This was illustrated with anaphors like *so* that pick up such propositional discourse referent. We then considered phenomena of conversation, which we modelled within the framework of commitment spaces, which contains a notion of common ground with continuations. In speech acts like an assertion or a question, the speaker commits to a proposition, or expects the addressee to commit to a

proposition, and it depends on the reactions of the speaker whether this proposition actually is admitted to the common ground. We have seen how responses like *yes*, *no*, *okay* and others can be understood as confirming a propositional discourse referent, or its negation, or expressing objection or non-objection against it. The theoretical proposal is quite complex because it incorporates the mechanisms of conversation into the notion of common ground itself, instead of relying on extraneous rules that work alongside of it.

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