Update conditions and intensionality in a type-theoretic approach to dialogue semantics

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Abstract

We consider the interaction of update conditions for dialogue gameboards, compositional semantics and intensionality. We will concentrate on the update conditions associated with proper names and definite descriptions. It is well-known from the literature that proper names require the dialogue partner being addressed to be able to identify an individual with the appropriate name or at least a role for an individual of that name in the content of the dialogue. Slightly more controversially we will take standard uses of definite descriptions to require the dialogue partner to be able to identify (a role for) a unique individual of that description. A puzzling example from this perspective is:

(opening presents on Christmas morning – A and B have failed to get a trainset for Sam)

A: Sam is looking for the trainset
B: What trainset?
A: The one he was promised for Christmas

We will present an analysis of this in which B is required to accommodate a *type* of a situation in which there is a unique trainset.

1 Introduction

In classical formal semantics (Montague, 1973; Montague, 1974) proper names are treated as denoting the set of properties of a unique individual and singular definite descriptions are given a Russellian analysis. Neither of these analyses introduce any kind of presupposition or familiarity requirement. In dynamic semantics (Heim, 1982; Kamp, 1981; Kamp and Reyle, 1993) linguistic content is viewed in terms of update potential and familiarity constraints are introduced in respect of definite and indefinite noun-phrases. However, this work was discourse oriented and did not take into account the updating of individual dialogue participants' gameboards as in the work of Ginzburg (1994; 2012). For recent discussions of alternatives presented in the voluminous literature on the semantic treatment of singular definite descriptions see Elbourne (2012) and Coppock and Beaver (2012).

In this paper we will adopt more or less the approach of Ginzburg (2012) but try to combine it with the rigorous approach to compositional semantics introduced by Montague (1973). In the process we will show that we can treat a kind of intensionality that arises in dialogical exchange that we believe has not been treated previously in the literature on dialogue semantics. It seems also to be a kind of intensional construction which potentially poses challenges for current treatments of definiteness in general in compositional semantics, though I am not yet in a position to evaluate which current proposals might successfully compete with the proposal here. The main aim of this paper is to get a closer connection between dialogue semantics and *some* kind of compositional semantics applied to a traditional semantic concern.

The basic data we wish to account for concerns (somewhat modestly in terms of modern semantics) proper names and singular definite descriptions. If A says (1) to B, then B is required to have a gameboard which somehow identifies an individual named Sam before the content of (1) can be integrated into B's gameboard.

(1) Sam left

If B's gameboard does not provide such an individual then some kind of accommodation has to take place. We will try to say something about the nature of the accommodation processes which might be involved, including one where B is not acquainted with an individual named Sam but relies on the fact that A has identified such an individual. Similarly, if A says (2) to B, then B's gameboard must contain information which enables him to identify a unique dog before the content of (2) can be integrated into his gameboard.

(2) The dog left

If the gameboard does not provide such an individual then some kind of accommodation has to take place, including one possibility where B is not himself able to identify an appropriate individual but relies on A being able to do so. We will take a rather conservative approach to definite descriptions, using a variant of Montague's (1973) Russellian approach combined with a notion of resource situation (Barwise and Perry, 1983; Cooper, 1996) in which there is a unique individual which falls under the description.

This choice plays a role when we consider the analysis of examples involving intensional constructions. Consider (3) which is a constructed dialogue based on a non-dialogical example presented by Max Cresswell.

(3) *(opening presents on Christmas morning – A and B have failed to get a trainset for Sam)*
A: Sam is looking for the trainset
B: What trainset?
A: The one he was promised for Christmas

The intended reading for A's first utterance is a *de dicto* one where the definite description *the trainset* is within the scope of the intensional verb *look for*.[1] There is no trainset under the Christmas tree. Both A and B know this and one senses a drama about to unfold. As one might expect on such a reading there is no requirement that B be able to identify a unique trainset on the basis of his gameboard. Furthermore, this is distinct from the non-intensional cases above where B had the option of relying on A being able to identify the appropriate trainset. There simply is no trainset which Sam is looking for. That, one suspects, is the point of A's initial remark. B knows there is no trainset. It is not the case that B misinterprets A's assertion as *de re*, that is, as referring to some particular physically existing trainset. That certainly would be a possible interpretation in a different context. But here, we assume, the background to this dialogue could be that A and B promised Sam a trainset for Christmas and agreed that B should buy it. B has subsequently forgotten this promise and knows that no trainset has been bought. Thus the clarification request is not a request for a reference to any particular physically existing trainset, but rather a request for an explanation of why a trainset is expected to be under the tree. This is potentially a problem for previous treatments of clarification such as Ginzburg and Cooper (2004), Purver and Ginzburg (2004), Ginzburg (2012) and Cooper (2013) where clarification is treated in terms of providing values for referential parameters.

If we think of the prior gameboard requirements engendered by utterances as being like presuppositions then it seems natural for the embedding of a noun-phrase in the scope of an intensional verb to block their projection to the root of a sentence in a compositional semantics. But there is, of course, a problem with this, as shown by (3). If the requirement that there is a unique trainset is blocked compositionally by the intensional verb how is it that B can ask his clarification question and A can give her answer, apparently referring to a trainset? Our proposed solution to this will treat the intensional verb as a *filter* rather than a *plug* (Karttunen, 1973). Our analysis will exploit the fact that we are using type theory in the manner proposed by Ginzburg (2012) and Cooper (2012). We shall propose that what gets passed up is not the requirement that the gameboard identifies a unique trainset but that an appropriate *type* of situation where there is a unique trainset is available on the gameboard. It will be important for our analysis that we are dealing not with traditional presuppositions but with constraints on gameboards. Whereas it may be trivial to claim that a given type exists, it is another matter altogether to require that an agent has such a type available on their gameboard.

The "type of situations where there is a unique trainset" is not of itself a very informative type. We can understand why B may ask a clarification question. We will suggest that the effect of B's question is to ask for a subtype of this type in

[1]The alternative is a *de re* reading where *the trainset* has wide scope outside of the scope of *look for*. This would, for example, be appropriate for a situation where there is a particular trainset under the Christmas tree and Sam is looking for the appropriate parcel.

which more information is given about the trainset involved in a situation of this type. A's response to the clarification request is a noun-phrase similar to examples discussed by Hulsey and Sauerland (2006) and Grosu and Krifka (2007). One may think that it is ambiguous between an extensional reading where it refers to a particular existing trainset and a "reconstructed" reading where the semantic contribution of the head is embedded below *promised*. We will claim below that despite the fact that there is no trainset it is the extensional reading that is relevant here and that the intensionality derives from an update process akin to modal subordination (Roberts, 1987). In this case there is no modal and we will call the process *type subordination*. The idea is that the clarification response is used to update a "subordinate" type introduced within the type representing the commitments (or FACTS) on the gameboard. In this case the updated type will be the "type of situations containing a unique trainset which was promised to Sam for Christmas".

2 Proper names

We will follow Ginzburg (2012) in using TTR (Type Theory with Records) (Cooper, 2012) to model both dialogue gameboards and compositional semantics. For orientation, we will first show how to recapture something very close to Montague's (1973) original treatment of proper names within TTR. We will then show how this can be modified into a semantics introducing update conditions.

Intransitive verbs like *leave* have as their content functions which map records containing an individual to a type of situations where that individual leaves.[2] (4a) is the function which is the content of *leave* and (4b) is the type to which the content of intransitive verbs are required to belong. Hence (4a) is of the type (4b).

(4) a. $\lambda r{:}\left[\text{x:}\mathit{Ind}\right].\ \left[\text{e:leave}(r.\text{x})\right]$[3]

b. $(\left[\text{x:}\mathit{Ind}\right]\rightarrow \mathit{RecType})$

c. *Ppty* – "property"

We abbreviate the type (4b) as (4c), that is the type of properties. Properties map a record containing an individual in a field labelled 'x' to a record type containing a type of situation. Record types serve as propositions. They are "true" if there is a situation of the type and false otherwise. The type *Ppty* corresponds to the type $\langle e, t\rangle$ in Montague semantics, mapping individuals to truth-values except we map to a type corresponding to a "proposition" so we are closer to the type $\langle e, p\rangle$, functions from individuals to propositions, introduced by Thomason (1980) and work in property theory as in for example Fox and Lappin (2005).

Montague's (1973) treatment of proper names was to treat them as functions from properties of individuals to truth values. To mimic this treatment we treat them as functions from properties to record types (corresponding to types of situations or "propositions"). That is, functions of the type (5a).

(5) a. $(\mathit{Ppty}\rightarrow \mathit{RecType})$

b. *Quant*

c. $\lambda P{:}\mathit{Ppty}.\ P(\left[\text{x=sam}\right])$

The notation r.x refers to the object in the x-field in the record r. We abbreviate (5a) as (5b) indicating that we are following Montague in treating noun-phrases as (generalized) quantifiers (Barwise and Cooper, 1981). (5c) is our reconstruction of Montague's basic treatment of the noun-phrase *Sam* where we use 'sam' to represent a particular individual.

Interpreting the sentence *Sam left* involves applying the function (5c) to (4a) which (after two applications of β-reduction[4]) returns (6), that is, a type of situations where Sam left.

(6) $\left[\text{e:leave(sam)}\right]$

We shall address two problems with this basic treatment of proper names: (i) it does not account for the fact that a proper name can refer to different individuals, an important source of misunderstanding which we wish to be able to analyze in dialogue semantics (ii) it does not give us any way of placing the requirement on the interlocutor's gameboard that there already be a person named Sam available in order to integrate the new information onto the gameboard. As Ginzburg (2012) points out, the successful use of a proper name

[2]We will not treat tense here.

[3]In contrast to Cooper (2012) and elsewhere, we will use the dot-notation for λ-abstraction. We previously would have represented this function as: $\lambda r{:}\left[\text{x:}\mathit{Ind}\right]\ (\left[\text{e:leave}(r.\text{x})\right])$.

[4]See Cooper (2012), section 2.8 for a presentation of the rather special nature of function application in TTR.

to refer to an individual a requires that the name be publically known as a name for a. We shall address both of these problems by making the interpretation of the proper name be a function that maps a context – that is, a situation modelled as a record (Ginzburg, 2012) – to a quantifier. That is, a function of type (7a).

(7) a. (*Rec*→*Quant*)

b. $\lambda r{:}\begin{bmatrix}\text{x:}\mathit{Ind}\\ \text{e:named(x, “Sam”)}\end{bmatrix}.$
$\lambda P{:}\mathit{Ppty}.\ P(r)$

The basic idea is that this function (7b) can be used to update a context of the type specified for the first argument of the function, i.e. a context where there is an individual named Sam. We will change all interpretations to be such “update functions”. In this paper we are not interested in specifying what requirements the intransitive verb *leave* may place on the context so we will let it be defined on any context (that is, any record) and will define it to be a function that returns (4a) no matter what the context is. The new function is given in (8).

(8) $\lambda r_1{:}\mathit{Rec}.\lambda r_2{:}\begin{bmatrix}\text{x:}\mathit{Ind}\end{bmatrix}.\ \begin{bmatrix}\text{e:leave}(r_2\text{.x})\end{bmatrix}$

We use (9a) as the general schema of functions which combine the interpretations of two constituents α and β.[5]

(9) a. $\lambda z.\alpha(z)(\beta(z))$

b. if $\alpha : (T_1 \rightarrow (T_2 \rightarrow T_3))$ and
$\beta : (T_4 \rightarrow T_2)$
then the *combination of* α *and* β *based on functional application* is
$\lambda r{:}\begin{bmatrix}\text{f:}{T_1}^{\text{f.}}\\ \text{a:}{T_4}^{\text{a.}}\end{bmatrix}.\ \alpha(r\text{.f})(\beta(r\text{.a}))$

c. $\lambda r{:}\begin{bmatrix}\text{f:}\begin{bmatrix}\text{x:}\mathit{Ind}\\ \text{e:named(f.x, “Sam”)}\end{bmatrix}\\ \text{a:}\mathit{Rec}\end{bmatrix}.$
$\begin{bmatrix}\text{e:leave}(r\text{.f.x})\end{bmatrix}$

(9b) is the combination rule we use. Note that the types T_1 and T_4 represent the restrictions on the context associated with α and β respectively and that both these restrictions are passed up to the combined interpretation, though embedded under the additional labels ‘f’ and ‘a’ respectively (mnemonics for “function” and “argument”). The reason for the addition of these labels is to avoid any unwanted label clash if T_1 and T_4 should happen to contain the same label. The notation $T^{\pi.}$ where π is a path (a sequence of labels) means a type like T except that any path that occurs as an argument to a predicate is prefixed by π. (9c) is the result of combining (7b) and (8) using (9b), after β-reduction.

How do we use (9c) to place constraints on the interlocutor’s gameboard? The idea is that the domain type in (9c) should be used to place a requirement on what is already present in the gameboard. The part of the gameboard that is relevant is that which represents the agent’s view of what has been established in the dialogue so far, that is the field which is labelled FACTS in Ginzburg (2012) and commitments in Larsson (2002) and Larsson and Traum (2001) and other work in the computational information state approach based on Ginzburg’s gameboard theory. Both Ginzburg and Larsson regard this field as containing a set of propositions. Ginzburg (2012) furthermore regards the propositions as being Austinian, that is, records each with a field for a situation and a type. What we shall use for update here, however, is a single record type which is used to keep track of the collected content of the dialogue. It seems much easier to understand how to use the kind of update functions discussed above to update this type. It corresponds to proposals within DRT for using a single DRS to keep track of the contribution of a discourse and to express anaphoric relations across sentences in a discourse. This is not meant as an argument against using Austinian propositions which seem independently useful. Perhaps the gameboard needs to contain a set, sequence or string of Austinian propositions in addition to the kind of type that we are talking about. It seems that our record type could be derived from a string or sequence of propositions representing the history of propositional updates to the gameboard by merging all the types in the Austinian propositions into a single large type which represents the commitment of the dialogue to the existence of a situation of that type. We will, however, not pursue this further in this paper.

[5]This is the λ-calculus version of the S-combinator in combinatorial logic. It is the standard manoeuvre for combining meanings, that is functions from context to contents, in compositional semantics, where the content of a phrase is the result of applying the content of one constituent to the content of the other constituent.

(10) a. $T_{i+1} = \left[\text{pr:}T_i^{\text{pr.}}\right] \mathbin{\dot\wedge} T_j$

b. *A boy hugged a dog. A girl stroked a cat*

c. $$\begin{bmatrix} \text{pr} & : & \begin{bmatrix} \text{pr:}\textit{Rec} \\ \text{x:}\textit{Ind} \\ \text{c}_{\text{boy}}\text{:boy(pr.x)} \\ \text{y:}\textit{Ind} \\ \text{c}_{\text{dog}}\text{:dog(pr.y)} \\ \text{e:hug(pr.x,pr.y)} \end{bmatrix} \\ \text{x} & : & \textit{Ind} \\ \text{c}_{\text{girl}} & : & \text{girl(x)} \\ \text{y} & : & \textit{Ind} \\ \text{c}_{\text{cat}} & : & \text{cat(y)} \\ \text{e} & : & \text{stroke(x,y)} \end{bmatrix}$$

(11) a. *A boy hugged a dog. He stroked a cat*

b. $$\begin{bmatrix} \text{pr} & : & \begin{bmatrix} \text{pr:}\textit{Rec} \\ \text{x:}\textit{Ind} \\ \text{c}_{\text{boy}}\text{:boy(pr.x)} \\ \text{y:}\textit{Ind} \\ \text{c}_{\text{dog}}\text{:dog(pr.y)} \\ \text{e:hug(pr.x,pr.y)} \end{bmatrix} \\ \text{x=pr.x} & : & \textit{Ind} \\ \text{c}_{\text{male}} & : & \text{male(x)} \\ \text{y} & : & \textit{Ind} \\ \text{c}_{\text{cat}} & : & \text{cat(y)} \\ \text{e} & : & \text{stroke(x,y)} \end{bmatrix}$$

We will thus assume that the commitments of the dialogue are kept track of in a field on the gameboard which contains a single type. Initially, before any commitments have been made in the dialogue, this type will be *Rec*, the type of records. The basic rule for updating a commitments type T_i with a new type T_j to obtain the current commitments type T_{i+1} is given in (10a). The label 'pr' ("previous") is used to ensure that label clash does not occur and it also gives us a way of maintaining a record of the order in which various commitments were introduced. Previous contributions become more and more deeply embedded as the dialogue progresses. This is represented by (10c) which shows one possible way of representing the commitments of the discourse (10b). The boy and the dog are held distinct from the girl and the cat despite the fact that the labels 'x' and 'y' have been reused. The symbol $\dot\wedge$ in (10a) represents the merge operation on types as discussed in Cooper (2012). In the simplest case for record types which do not share any labels this involves forming a type with the union of the two sets of fields from the types being merged. (11) gives a hint of the general strategy for treating anaphora in such a system, although that is not the subject of the present paper.

Here we use a manifest field $\left[\text{x=pr.x:}\textit{Ind}\right]$ (Cooper, 2012) which requires that the individual in the x-field is identical to the individual in the pr.x-field.

The strategy of updating types in this way to model growing numbers of commitments as the dialogue progresses is essentially similar to using a DRS to keep track of commitments. Types can, among other things, model DRSs and our use of types in modelling gameboards might be seen as related to the psychological perspective on DRT presented by Zeevat (1989). Thinking of commitments in terms of a type which grows during the course of a dialogue is also closely related to Stalnaker's (1978; 2002) notion of common ground. Instead of thinking of an agent's view of the common ground as being a set of possible worlds which gets smaller as the dialogue progresses we think of it as a type of situation which gets more refined and thus places more restrictions on the nature of the situation corresponding to the commitments.

Suppose that the commitments type on the gameboard is (12a). According to (9c), we are wanting to match (12a) with the type (12b).

(12)

a. $$\left[\begin{array}{l} \text{pr:}\left[\begin{array}{l} \text{pr:}\mathit{Rec} \\ \text{x:}\mathit{Ind} \\ \text{c}_{\text{boy}}\text{:boy(pr.x)} \\ \text{c}_{\text{named}}\text{:named(pr.x, “Sam”)} \\ \text{y:}\mathit{Ind} \\ \text{c}_{\text{dog}}\text{:dog(pr.y)} \\ \text{e:hug(pr.x,pr.y)} \end{array}\right] \\ \text{x:}\mathit{Ind} \\ \text{c}_{\text{girl}}\text{:girl(x)} \\ \text{y:}\mathit{Ind} \\ \text{c}_{\text{cat}}\text{:cat(y)} \\ \text{e:stroke(x,y)} \end{array}\right]$$

b. $$\left[\begin{array}{l} \text{f:}\left[\begin{array}{l} \text{x:}\mathit{Ind} \\ \text{e:named(f.x, “Sam”)} \end{array}\right] \\ \text{a:}\mathit{Rec} \end{array}\right]$$

c. $$\left[\begin{array}{lll} \text{pr.pr} & : & \mathit{Rec} \\ \text{pr.x} & : & \mathit{Ind} \\ \text{pr.c}_{\text{boy}} & : & \text{boy(pr.x)} \\ \text{pr.c}_{\text{named}} & : & \text{named(pr.x, “Sam”)} \\ \text{pr.y} & : & \mathit{Ind} \\ \text{pr.c}_{\text{dog}} & : & \text{dog(pr.y)} \\ \text{pr.e} & : & \text{hug(pr.x,pr.y)} \\ \text{x} & : & \mathit{Ind} \\ \text{c}_{\text{girl}} & : & \text{girl(x)} \\ \text{y} & : & \mathit{Ind} \\ \text{c}_{\text{cat}} & : & \text{cat(y)} \\ \text{e} & : & \text{stroke(x,y)} \end{array}\right]$$

d. $$\left[\begin{array}{lll} \text{pr.x} & : & \mathit{Ind} \\ \text{pr.c}_{\text{named}} & : & \text{named(pr.x, “Sam”)} \\ \text{pr.pr} & : & \mathit{Rec} \end{array}\right]$$

What we would like is for (12a) to be a subtype of (12b), that is, any situation of type (12a) is also of type (12b). But this is manifestly not the case. The labels do not match, for one thing. And yet intuitively there should be a match here. (12b) requires that there is an individual named Sam in any situation of the type and so does (12a). Our intuition rests on the equivalences of relabelling and flattening records that Cooper (2012) discusses.[6] We extend this flattening to types. If we flatten (12a), using complex labels so that we can get back to the unflattened type if we want, we obtain (12c). If we flatten and relabel (12b) with appropriate labels from (12c) we can obtain (12d). (12c) is a subtype of (12d).[7]

Let us summarize what we have done here a little more formally. We will use η as a variable over relabellings of a type and say that $\eta(T)$ is the result of relabelling T by η. We will use $\varphi(T)$ to represent the result of flattening T and φ^{-} to represent the inverse of flattening. (Thus $\varphi^{-}(\varphi(T)) = T$.) If f is a function returning types, a dependent type, we will use $\mathfrak{F}(f)$ to denote the fixed point type of f following (Cooper, 2012).[8] This is the type obtained by merging the domain type of the function with the type it returns, adjusting labels as necessary. If $f : T_1 \rightarrow T_2$ is an update function and T is a type (corresponding to commitments on the gameboard), then f can update T iff there is some relabelling η of $\varphi(T_1)$ such that $\varphi([\text{pr} : T]) \sqsubseteq \eta(\varphi(T_1))$. The result of updating T with f is then $\varphi^{-}(\varphi([\text{pr} : T]) \wedge\!\!\!\!\cdot\;\, \eta(\varphi(\mathfrak{F}(f))))$. Suppose we want to update T with (9c). We first check that the flattening of [pr:T] is a subtype of some relabelling, η, of the flattening of (12b), that is the domain type of the function. If this holds, then we can update by merging the two flattened types and then reversing the flattening.

What happens if a match is not found and we are therefore unable to update the gameboard? Then accommodation must take place. We assume the kind of model discussed in Cooper and Larsson (2009) and Larsson and Cooper (2009) where not only a gameboard is present (a kind of short term memory) but also resources (a kind of long term memory). We think of one kind of accommodation as finding a match in the resources and “loading” this into the gameboard. If we think of resources as providing a record type or a collection of record types modelling long term memory, then the accommodation process could build on the techniques we have described here for update. The accommodation would involve first updating the gameboard with a subtype of the type required by the dialogue contribution we are trying to integrate. This subtype would be derived from the resources. It seems reasonable to suppose that the type found should be a proper subtype of the one required by the utterance, that is a type which provides more information that is presupposed by the utterance. This seems important to model intuitive notions of “identifying” objects,

[6]Flattening in TTR is conceptually related to the notion of path equation in Lexical Functional Grammar (Dalrymple et al., 1995).

[7]The order of the fields in our notation is not significant since record types are modelled as sets of ordered pairs (Cooper, 2012).

[8]Note that while there may not always be a fixed point for such a function, that is, some a such that $a : f(a)$, there will be a fixed point *type*, which may be empty.

that is, being able to provide further information about them. Now the gameboard will meet the requirements of the dialogue contribution we are trying to integrate and we can proceed with the update. Another kind of accommodation can be used in a situation where the resources do not provide an appropriate type. This involves updating the gameboard with the required type even though you did not have a match for it. Our suggestion would be that the update algorithm first looks for a match on the gameboard, then if that fails, in the resources and if that fails too, simply adding the required type. This process must also interact with clarification strategies. Clarification may be used either in the case where no match is found or more than one match is found. Of course, there can be other factors involved besides simply finding a match. For example, you may have reference to a person named Sam in your resources but you know that there is no way that your interlocutor could know about that particular Sam – thus it is a matter not just of finding a match but also an appropriate match or at least a match for which you do not have evidence that it is inappropriate.

3 Definite descriptions

For orientation, we will start our discussion of definite descriptions by mimicking Montague's (1973) treatment. We will use (13a) to represent the property of being a dog, that is, (13b).

(13) a. dog′

b. $\lambda r{:}\begin{bmatrix}\text{x:}\textit{Ind}\end{bmatrix}.\ \begin{bmatrix}\text{e:dog}(r.\text{x})\end{bmatrix}$

c. $\lambda P{:}\textit{Ppty}.\ \begin{bmatrix}\text{e:the(dog}',\text{P)}\end{bmatrix}$

d. $[\downarrow P] =$
$\{a \mid \exists r[r : \begin{bmatrix}\text{x:}\textit{Ind}\end{bmatrix} \wedge r.\text{x} = a \wedge [\check{}P(r)] \neq \emptyset]\}$
where for any type T,
$[\check{}T] = \{a \mid a : T\}$

e. $[\check{}\text{the}(P, Q)] \neq \emptyset$ iff
$\mid [\downarrow P] \mid = 1$ and $[\downarrow P] \subseteq [\downarrow Q]$

Then Montague's generalized quantifier treatment of definite descriptions is exemplified by (13c). This is the treatment of generalized quantifiers in TTR presented by Cooper (2011) and Cooper (2013). If P is a property, then we use $[\downarrow P]$ to represent the set of individuals that have P, as defined in (13d). Then we can say that the(P,Q) is a non-empty situation type (is "true") just in case $[\downarrow P]$ has exactly one member and $[\downarrow P]$ is a subset of $[\downarrow Q]$, as stated in (13e). This is a variant of the Russellian treatment of definite descriptions. It does not have any presuppositional element, that is, in our terms, it does not place any requirements on the interlocutor's gameboard in order to allow update. Furthermore it requires uniqueness apparently *tout court* rather than limited to a particular situation.

We fix the second problem first by introducing a resource situation (Barwise and Perry, 1983; Cooper, 1996). We allow properties to be restricted to a particular situation. Thus dog′$\restriction s$ will be used to represent the property of being a dog in s as defined in (14a).

(14) a. $\lambda r{:}\begin{bmatrix}\text{x:}\textit{Ind}\end{bmatrix}.\ \begin{bmatrix}\text{e=}s\text{:dog}(r.\text{x})\end{bmatrix}$

b. $\lambda r{:}\begin{bmatrix}\text{s:}\textit{Rec}\\ \text{e:unique(dog}',\text{s)}\end{bmatrix}.$
$\lambda P{:}\textit{Ppty}.\ \begin{bmatrix}\text{e:every(dog}'\restriction r.\text{s},P)\end{bmatrix}$

c. $[\check{}\text{unique}(P, s)] \neq \emptyset$ iff $\mid [\downarrow P \restriction s] \mid = 1$

This notion of resource situation can then be exploited in an update interpretation for the definite description as in (14b). Here the predicate 'unique' is characterized as in (14c). That is, unique(P,s) holds just in case the set of individuals which have the property P restricted to s has exactly one element. This interpretation can combine with the interpretation of *left* and be matched against the commitments type on an agent's gameboard in an exactly similar fashion to that discussed in the preceding section.

We now consider the treatment of intensional verbs such as *look for*. If we follow Montague's original treatment the interpretation of *Sam is looking for the trainset* would involve the type of situations in (15a). If we adjust this using the kind of update functions we have suggested and the combination rule corresponding to functional application suggested in the previous section, we would obtain (15b). This is incorrect for the intensional reading since it requires the interlocutor to find a relevant situation with a unique trainset but in (3) both dialogue participants know that there is no trainset. We might then take inspiration from Montague's intensional analysis and say that the second argument to 'look_for' is the update function itself, not the result of applying it to a context. This would give us (15c). This seems hopeful, but it is still not quite right. Now *the trainset*

(15)

a. $$\left[\begin{array}{l}\text{e:look\_for(sam,}\\ \qquad \lambda P{:}\textit{Ppty}.\ \left[\text{e:the(trainset}',P)\right])\end{array}\right]$$

b. $$\lambda r{:}\left[\begin{array}{l}\text{f:}\left[\begin{array}{l}\text{x:}\textit{Ind}\\ \text{e:named(f.x, “Sam”)}\end{array}\right]\\ \text{a:}\left[\begin{array}{l}\text{f:}\textit{Rec}\\ \text{a:}\left[\begin{array}{l}\text{s:}\textit{Rec}\\ \text{e:unique(trainset}',\text{a.a.s)}\end{array}\right]\end{array}\right]\end{array}\right].$$
$$\left[\begin{array}{l}\text{e:look\_for(}r\text{.f.x, }\lambda P{:}\textit{Ppty}.\\ \qquad \left[\text{e:every(trainset}'\upharpoonright r\text{.a.a.s, }P)\right])\end{array}\right]$$

c. $$\lambda r_1{:}\left[\begin{array}{l}\text{f:}\left[\begin{array}{l}\text{x:}\textit{Ind}\\ \text{e:named(f.x, “Sam”)}\end{array}\right]\\ \text{a:}\left[\begin{array}{l}\text{f:}\textit{Rec}\\ \text{a:}\textit{Rec}\end{array}\right]\end{array}\right].$$
$$\left[\begin{array}{l}\text{e:look\_for(}r_1\text{.f.x,}\\ \qquad \lambda r_2{:}\left[\begin{array}{l}\text{s:}\textit{Rec}\\ \text{e:unique(trainset}',\text{a.a.s)}\end{array}\right].\\ \qquad\quad \lambda P{:}\textit{Ppty}.\\ \qquad\qquad \left[\text{e:every(trainset}'\upharpoonright r_2\text{.s, }P)\right])\end{array}\right]$$

d. $$\lambda r_1{:}\left[\begin{array}{l}\text{f:}\left[\begin{array}{l}\text{x:}\textit{Ind}\\ \text{e:named(f.x, “Sam”)}\end{array}\right]\\ \text{a:}\left[\begin{array}{l}\text{f:}\textit{Rec}\\ \text{a=}\left[\begin{array}{l}\text{s:}\textit{Rec}\\ \text{e:unique(trainset}',\text{s)}\end{array}\right]\text{:}\textit{RecType}\end{array}\right]\end{array}\right].$$
$$\left[\begin{array}{l}\text{e:look\_for(}r_1\text{.f.x,}\\ \qquad \lambda r_2{:}r_1\text{.a.a .}\\ \qquad\quad \lambda P{:}\textit{Ppty}.\\ \qquad\qquad \left[\text{e:every(trainset}'\upharpoonright r_2\text{.s, }P)\right])\end{array}\right]$$

e. if $\alpha : (T_1 \rightarrow ((T_4 \rightarrow T_2) \rightarrow T_3))$ and $\beta : (T_4 \rightarrow T_2)$ then the *combination of α and β based on intensional functional application* is

$$\lambda r_1{:}\left[\begin{array}{l}\text{f:}{T_1}^{\text{f.}}\\ \text{a=}T_4\text{:}\textit{Type}\end{array}\right].$$
$$\alpha(r_1.\text{f})(\lambda r_2 : r_1.a\ .\ \beta(r_2))$$

equivalently:

$$\lambda r_1{:}\left[\begin{array}{l}\text{f:}{T_1}^{\text{f.}}\\ \text{a=}T_4\text{:}\textit{Type}\end{array}\right].\ \alpha(r_1.\text{f})(\beta)$$

is not placing any requirement on the interlocutor's gameboard and yet our intuitions and the evidence from (3) suggest that the interlocutor needs to know "which trainset is being talked about" without this entailing a commitment to there being such a trainset. How can this be? If we talk in presupposition terms 'look_for' is behaving as a hole according to (15b) and as a plug according to (15c). The remaining option is that it behaves as a filter, that is, it projects up a modification of the presupposition associated with *the trainset*. Our analysis will say that instead of projecting up the requirement that there is a situation with a unique trainset, the projected requirement is that a type of situation with a unique trainset is available on the gameboard without any requirement of there being something of this type. The analysis is given in (15d). The general combination rule, which should be compared with (9b), is given in (15e).[9]

In (3), dialogue participant B is clearly in accommodation mode, and, following our discussion at the end of the previous section, in difficulty trying to find a proper subtype of the type required by *the trainset* – hence, B's clarification request. Intuitively, A's response to the clarification request should provide that subtype, though at the time of writing it is a little unclear how we show technically that the interpretation of the noun-phrase provides a subtype. At this point in the dialogue, we suggest, the discussion is subordinated to that type which is to be placed on the gameboard. Thus it is that type which for the period of the subordination as if it is the type representing all the commitments on the gameboard. Once the type has been specified it will be inserted as a type in a field in the commitments type, requiring the type to be available but not requiring that there be anything of the type. This seems to provide a way of thinking about a number of different examples of intensional identity across dialogue turns, though working out the exact details of the mechanisms involved belongs to the realm of future work.

4 Conclusion

We have proposed a compositional treatment of proper names and definite descriptions using TTR

[9] In a fully explicit treatment this would require α to have a polymorphic type since in general the domain type of β could be any record type thus requiring α to apply to functions from a range of types. A similar situation in connection with the analysis of generalized quantifiers is discussed in Cooper (2011).

which makes a tight coupling between a compositional update semantics and the theory of dialogue gameboards. We have suggested that this provides a rather natural treatment of an otherwise puzzling phenomenon when definite descriptions are embedded below intensional verbs. We have sketched how this compositional semantics could interact with a theory of accommodation and clarification interactions, though this part of the theory is still in need of technical development.

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