Weak Familiarity and Anaphoric Accessibility in Dynamic Semantics*

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Abstract. The accessibility constraints imposed on anaphora by dynamic theories of discourse are too strong because they rule out many perfectly felicitous cases. Several attempts have been made by previous authors to rectify this situation using various tactics. This paper proposes a more viable approach that involves replacing Heim's notion of familiarity with a generalized variant due to Roberts. This approach is formalized in hyperintensional dynamic semantics, and a fragment is laid out that successfully deals with some problematic examples.

Keywords: anaphora, accessibility, familiarity, dynamic semantics, discourse

1 Overview

Dynamic theories such as discourse representation theory (DRT: Kamp 1981, Kamp and Reyle 1993), file change semantics (FCS: Heim 1982, 1983), and dynamic Montague grammar (DMG: Groenendijk and Stokhof 1991) are able to successfully treat 'donkey anaphora' because they appropriately constrain cross-clausal anaphoric links. Unfortunately, for certain classes of examples, these constraints are too strong. A number of attempts have been made to appropriate loosen these constraints in different frameworks using widely varying tactics, including scope extensions, so-called 'E-type' pronouns, and presupposition accommodation.

I argue below that these previous attempts miss an empirical generalization due to Roberts (2003) that many cases of seemingly inaccessible anaphora can be described by a weak variant of Heim's **familiarity**. I then show how Roberts' weak version of familiarity can be incorporated into a formal model of discourse following Martin and Pollard (in press, to appear). A fragment shows how the extended theory can deal with some recalcitrant counterexamples to Heim's familiarity-based theory. I also examine the possibility of further extending this theory with Roberts' **informational uniqueness** and give a discussion of its interaction with certain pragmatic effects.

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The rest of this paper is organized as follows. Section 2 describes the problem of anaphora occurring across inaccessible domains with motivating examples, and then lays out some other attempts to deal with it. In section 3, I discuss Heim's notion of (strong) familiarity and contrast it with Roberts' generalization of it to weak familiarity. An overview of Martin and Pollard's hyperintensional dynamic semantics (HDS) is given in section 4, along with some proposed extensions for modeling weak familiarity. This extended framework is then applied to some examples of anaphora across inaccessible domains in section 5, and a discussion of some apparent cases of overgeneration is provided. Section 6 summarizes and indicates some avenues for possible future work.

2 The Problem of Anaphora Across Inaccessible Domains

One of the central triumphs of dynamic semantic theories in the tradition of DRT, FCS, and DMG is that they make pronominal anaphora possible only under certain conditions. This notion of **anaphoric accessibility** explains the difference in felicity between the examples in (A) and (B).

(A) If Pedro owns $\left\{\begin{array}{r}\text{a}\\ \text{\#every}\end{array}\right\}$ donkey$_i$ he beats it$_i$.
(Kamp 1981, examples 1, 17)

(B) 1. Everybody found a cat$_i$ and kept it$_i$.
2. #It$_i$ ran away.
(Heim 1983, example 5)

In these examples, the quantifying expression *every* limits the anaphoric accessibility of discourse referents (DRs) introduced within its scope. The quantifier *no* exhibits similar behavior:

(C) 1. $\left\{\begin{array}{r}\text{A}\\ \text{\#No}\end{array}\right\}$ donkey$_i$ brays.
2. Its$_i$ name is Chiquita.

In (C), as in (A) and (B), a quantifying expression constrains the scope of DRs occurring in its scope in a way that the indefinite does not. Although it is encoded differently in each, DRT, FCS, and DMG tell very similar stories to explain these facts. These dynamic accounts of anaphoric accessibility rest on the same basic idea that indefinites introduce DRs and quantifiers limit the scope of DRs. Indefinites themselves do not place bounds on DR scope because they are treated either as non-quantifying (and thus as scopeless) or as extending their scope across discourse (unless they are outscoped by a 'true' quantifier). Many authors have subsequently adopted the essential details of this treatment of anaphoric accessibility (Chierchia 1992, 1995; van der Sandt 1992; Muskens 1994, 1996; Geurts 1999; Beaver 2001; de Groote 2006, 2008, among others).

However, the treatment of anaphoric accessibility found in dynamic semantics is not without problems, as the following 'bathroom' example[1] shows.

(D) Either there's no bathroom$_i$ in this house or it$_i$'s in a funny place. (Roberts 1989)

Examples like (D) seem to pose a direct counterexample to anaphoric inaccessibility: a DR introduced in the scope of a quantifier (here, *no*) is clearly accessible from pronouns that occur outside of the quantifier's scope. Unless somehow elaborated, a dynamic theory in the tradition of DRT/FCS/DMG would incorrectly predict that *bathroom* cannot serve as an antecedent for *it*.

This problem isn't simply limited to disjunctions or intrasentential anaphora, as (E) shows.

(E)
1. Every farmer owns a donkey.
2. Pedro is a farmer, and his donkey is brown.

The discourse in (E) is unproblematic. But the anaphoric accessibility constraints in dynamic theories would predict that the anaphora associated with *his donkey* is not resolvable. Yet we seem to have no problem understanding that Pedro's donkey ownership is a result of his being a farmer and the fact that, as previously mentioned, all farmers have a donkey. Various attempts have been made to square the idea of anaphoric accessibility with problematic examples like (D) and (E). I examine some of these attempts in the next section.

2.1 Some Attempts to Rectify the Problem

Groenendijk and Stokhof (1991) entertain the possibility of accounting for certain cases of anaphora in inaccessible domains by allowing some dynamic quantifiers and connectives to extend their scope further than the accessibility constraints dictate. The resulting extension of DMG accounts for the anaphora in examples involving disjunction such as (D), but it also gives rise to other undesirable predictions. For instance, the scope-extension variant of their theory is unable to rule out cases where anaphora is truly inaccessible, such as the following.

(F)
1. Every farmer owns a donkey$_i$.
2. # Pedro is a farmer, and he beats it$_i$.

(G)
1. Every farmer$_i$ owns a donkey.
2. # The farmer$_i$'s name is 'Pedro.'

For both (F) and (G), the proposed extension to DMG would allow the pronoun in the second utterance to have as its antecedent the indicated DR in the first utterance.

[1] Example (D) is attributed to Barbara Partee both by Roberts and by Chierchia (1995, p. 8), who gives a slight variant of it. A similar class of examples is discussed by Evans (1977).

In Chierchia (1995), an ambiguity is posited for pronouns between the "dynamically bound" case (in which the accessibility constraints are followed) and the 'E-type' case of e.g. Cooper (1979), in which anaphora across inaccessible domains is allowable in certain cases. Chierchia successfully applies his theory both to donkey anaphora and to the bathroom sentence (D), and although he does not treat parallel examples, a straightforward account of (E) in Chierchia's theory using an E-type pronoun for *his* is not beyond imagination. However, even leaving aside the arguments advanced by Roberts (2004) against the viability of the E-type approach in general, it would be desirable if a single mechanism could account for discourse anaphora without needing an ambiguity between dynamically bound and E-type pronouns. Below, I argue that such a unified treatment of pronominal anaphora in discourse is possible.

Lastly, an approach to bathroom sentences like (D) is laid out in Geurts (1999), which in turn is an extension of the presuppositional DRT of van der Sandt (1992). In this theory, the anaphora in (D) is treated as an instance of presupposition accommodation: an antecedent for the pronoun *it* is added to the right disjunct in order to allow felicitous interpretation. I would argue that construing such examples as involving accommodation is somewhat odd, since felicitous interpretation actually seems to require an overt (non-accommodated) antecedent. To illustrate this, consider the following example, which contains only the right disjunct of (D).

(H) #It's in a funny place.

The use of the pronoun in (H) gives rise to infelicity because no antecedent can be found. Yet Geurts seems to predict that an antecedent would simply be accommodated in a way similar to the accommodation that his theory predicts for (D). Similarly, Geurts predicts that an antecedent for *his donkey* in (E) must be accommodated into the global discourse context in order for it to be felicitous. Yet the fact that Pedro is a farmer, coupled with the fact that every farmer owns a donkey, seems to be what allows the anaphora in *his donkey* to be resolved. I present an account below in which the seemingly accessible NPs *a bathroom* in (D) and *a donkey* in (E) are crucial to permitting the observed anaphoric links.

3 Strong and Weak Familiarity

For Heim (1982), a semantic representation containing a definite NP (e.g., a pronoun) requires for its felicity that the definite NP be **familiar** in the discourse context. Following Roberts (2003), I refer to Heim's notion of familiarity as the **strong** variant, for reasons that are clarified below. The details of Heim's formalization of strong familiarity are given in Defintion 1.

Definition 1 (Strong Familiarity). Let i be the index of a definite NP d in a semantic representation r. Then the DR i is **strongly familiar** in a discourse context c iff

1. The DR i is among the active DRs in c, and

2. If d has descriptive content, then c entails that i has the relevant descriptive content.

Heim's familiarity has the effect of requiring pronouns and other definites to have an adequate, previously established antecedent in the discourse context. The dynamic meanings of quantifiers, conditionals, etc. are then set up in a way that guarantees the anaphoric accessibility conditions discussed in section 2, above.

Taking (B) as an example, Heim's theory correctly predicts the felicity of the first occurrence of *it* and the infelicity of the second occurrence. The first *it* is meets the familiarity condition because an antecedent DR, introduced by *every*, is accessible. The second, however, is infelicitous because it occurs outside the scope of *every*, where no antecedent DR is available.

The problem of accounting for anaphora in inaccessible domains arises for Heim's theory as a direct result of her formulation of familiarity and the accessibility conditions on anaphora. For example, the familiarity condition requires that *his donkey* in (E) have an accessible DR in the discourse context that has the property of being a donkey. But since the donkey-DR introduced by *a donkey* in the first sentence of (E) has its accessibility limited by the scope of *every*, the occurrence of *his donkey* in the second utterance does not meet the familiarity condition. This is the reason Heim's theory incorrectly predicts infelicity for (E). The bathroom example (D) represents an analogous situation: the quantifier *no* limits the scope of the bathroom-DR introduced in the first conjunct, which results in the pronoun *it* failing to satisfy the condition for familiarity imposed on definites. Here again, Heim's theory predicts infelicity for a perfectly felicitous discourse.

Roberts (2003) reworks Heim's familiarity condition on definites into a more general notion of "weak" familiarity. In Definition 2, I give a simplified version of Roberts' formalization of this idea.

Definition 2 (Weak Familiarity). Let i be the index of a definite NP d in a semantic representation r. Then the DR i is **weakly familiar** iff c entails the existence of an entity bearing the descriptive content of d (if any).

As this definition shows, for a definite to be weakly familiar in a certain discourse context, the context does not necessarily have to contain an active DR with the relevant descriptive content, if any. Weak familiarity only requires that the discourse context entails that an entity bearing the relevant description exists.

For example, supplanting Heim's strong familiarity with Roberts' weak familiarity renders examples like (E) felicitous. The definite *his donkey* meets the weak familiarity condition because the discourse context entails that a donkey exists that is owned by Pedro. Example (D) is also felicitous under weak familiarity for a similar reason. Although the would-be antecedent *a bathroom* is inaccessible, its use in the first disjunct results in a discourse context that entails the existence of a bathroom. This entailment allows the pronoun *it* in the second disjunct to satisfy the weak familiarity condition.

As Roberts notes, the strong version of the familiarity condition, coupled with Heim's definitions for e.g. quantifiers, is essentially just anaphoric accessibility.

The reason weak familiarity is called 'weak' is that it subsumes strong familiarity: a definite's being strongly familiar entails that it is weakly familiar, but not the other way around. In the next section, I implement Roberts' more general weak familiarity into an essentially Heim-like formal theory of discourse.

4 A Formalization in Hyperintensional Dynamic Semantics

To formalize weak familiarity, I extend the hyperintensional dynamic semantics (HDS) of Martin and Pollard (in press, to appear), which implements a version of Heim's strong familiarity condition for definites. HDS is a theory of discourse built on the hyperintensional (static) semantics of Pollard (2008a, 2008b) that additionally extends the Montagovian dynamics of de Groote (2006, 2008). It is expressed in a classical higher-order logic (HOL) in the tradition of Church (1940), Henkin (1950), and Montague (1973) that is augmented with some of the extensions proposed by Lambek and Scott (1986), as I describe below. The next four sections are mostly review of HDS. Below, in section 4.5, I propose extensions to HDS for dealing with weak familiarity.

As usual, pairing is denoted by $\langle\ ,\ \rangle$. For f a function with argument x, application is written $(f\ x)$ rather than the usual $f(x)$. Application associates to the left, so that $(f\ x\ y)$ becomes shorthand for $((f\ x)\ y)$. Variables that are λ-abstracted over are written as subscripts on the lambda, following Lambek and Scott. Successive λ-abstractions are usually simplified by collapsing the abstracted variables together onto a single lambda, so that $\lambda_{xyz}.M$ is written instead of $\lambda_x\lambda_y\lambda_z.M$. I sometimes use the . symbol to abbreviate parentheses in the usual way, with e.g. $\lambda_x.M\ N$ shorthand for $\lambda_x(M\ N)$. Lastly, parentheses denoting application are sometimes omitted altogether when no confusion can arise.

4.1 Types and Constants

The basic types e of entities and t of truth values are inherited from the underlying logic, as are the usual type constructors U (unit), $\times$ (product), and $\rightarrow$ (exponential). HDS follows Lambek and Scott (1986) in adopting the following extensions to HOL:

- The type natural number type ω, which is linearly ordered by $<$ and equipped with the successor function $\mathsf{suc} : \omega \rightarrow \omega$.
- Lambda-definable subtypes: for any type A, if φ is a formula with $x : A$ free, then $\{x \in A \mid \varphi\}$ denotes the subtype consisting of those inhabitants of A for which φ is true.

A partial function from A to B is written $A \rightharpoonup B$, i.e., as a function from a certain subtype of A to B. I also use dependent coproduct types parameterized by ω, so that $\coprod_{n \in \omega} T_n$ denotes the dependent coproduct type whose cofactors are all the types T_n, for n a natural number. I sometimes drop the subscript denoting the natural number parameter when the parameter is clear from context.

Discourses generally involve a set of DRs. Accordingly, I introduce a set of subsets of ω:

$$\omega_n =_{\mathrm{def}} \{i \in \omega \mid i < n\}$$

Since natural numbers are used to represent DRs, the type ω_n is intuitively the first n DRs.

The type a_n of n-**anchors** are mappings from the first n DRs to entities, analogous to Heim's assignments.

$$\mathrm{a}_n =_{\mathrm{def}} \omega_n \to \mathrm{e}$$

The constant functions $\bullet_n : \mathrm{a}_n \to \mathrm{e} \to \mathrm{a}_{(\mathbf{suc}\ n)}$ extend an anchor to map the 'next' DR to a specified entity, subject to the following axioms:

$$\vdash \forall_{n\in\omega}\forall_{a\in\mathrm{a}_n}\forall_{x\in\mathrm{e}}.(a \bullet_n x)\, n = x$$
$$\vdash \forall_{n\in\omega}\forall_{a\in\mathrm{a}_n}\forall_{x\in\mathrm{e}}\forall_{m:\omega_n}.(a \bullet_n x)\, m = (a\, m)$$

These axioms together ensure that for an n-anchor a, the extended anchor $(a \bullet_n x)$ maps n to x, and that none of the original mappings in a are altered.

Relative salience for the DRs in an n-anchor is encoded by an n-resolution r_n, axiomatized as the subtype of binary relations on ω_n that are preorders (this property is denoted by preo_n):

$$\mathrm{r}_n =_{\mathrm{def}} \{r \in \omega_n \to \omega_n \to \mathrm{t} \mid (\mathsf{preo}_n\, r)\}$$

Analogously to anchors, an n-resolution can be extended to cover the 'next' DR using $\star_n : \mathrm{r}_n \to \mathrm{r}_{(\mathbf{suc}\ n)}$. For an n-resolution r, $(\star_n\, r)$ is the resolution just like r except that n is added and axiomatized to be only as salient as itself (and unrelated to any $m < n$).

I adopt the basic type p of propositions from Pollard's (2008b) static semantics. This type, which is preordered by the entailment relation $\mathsf{entails} : \mathrm{p} \to \mathrm{p} \to \mathrm{t}$, is used to model the **common ground (CG)** following Stalnaker (1978). Certain natural language entailments are central to the analysis of anaphora I propose below. The hyperintensional entailment axioms pertaining to the (translations of the) English 'logic words' that impact the analysis I propose in section 5 are given in Equations 1 through 5.

$$\vdash \forall_{p\in\mathrm{p}}.p\ \mathsf{entails}\ p \quad (1)$$
$$\vdash \forall_{p,q,r\in\mathrm{p}}.(p\ \mathsf{entails}\ q) \to ((q\ \mathsf{entails}\ r) \to (p\ \mathsf{entails}\ r)) \quad (2)$$
$$\vdash \forall_{p,q\in\mathrm{p}}.(p\ \mathsf{and}\ q)\ \mathsf{entails}\ p \quad (3)$$
$$\vdash \forall_{p,q\in\mathrm{p}}.(p\ \mathsf{and}\ q)\ \mathsf{entails}\ q \quad (4)$$
$$\vdash \forall_{p\in\mathrm{p}}.(\mathsf{not}\ (\mathsf{not}\ p))\ \mathsf{entails}\ p \quad (5)$$

The first two of these simply state that the entailment relation on p forms a preorder (reflexive, transitive relation). Equations 3 and 4 require that a conjunction of two propositions entails either conjunct, and Equation 5 axiomatizes double negation elimination. See Pollard (2008b, (42)–(44)) for a complete axiomatization of $\mathsf{entails}$.

Discourse contexts are defined as tuples of an anchor, resolution, and a CG, inspired both by Heim and by Lewis (1979).

$$\mathrm{c}_n =_{\mathrm{def}} \mathrm{a}_n \times \mathrm{r}_n \times \mathrm{p}$$
$$\mathrm{c} =_{\mathrm{def}} \coprod_{n \in \omega} \mathrm{c}_n$$

For each $n \in \omega$, a discourse context of type c_n is one that 'knows about' the first n DRs. The type c is simply the type of n-contexts of any arity.

Several functions are useful in HDS for managing discourse contexts. The projection functions for the three components of a context are mnemonically abbreviated as $\mathbf{a} : \mathrm{c} \to \mathrm{a}$ (for *anchor*), $\mathbf{r} : \mathrm{c} \to \mathrm{r}$ (for *resolution*) and $\mathbf{p} : \mathrm{c} \to \mathrm{p}$ (for *proposition*). As a shorthand, I further abbreviate $(\mathbf{a}cn)$, the entity anchoring the DR n in the context c, as follows.

$$\vdash \forall_{m \in \omega} \forall_{c \in \mathrm{c}_m} \forall_{n \in \omega_m}.[n]_c = (\mathbf{a}\, c\, n)$$

As long as no confusion is possible, I usually drop the subscript c and write simply $[n]$. The 'next' DR for an n-context is always the natural number n, retrievable by next_n:

$$\vdash \forall_{n \in \omega} \forall_{c \in \mathrm{c}_n}.(\mathsf{next}_n\ c) = n$$

The constants $::_n$ and $+_n$ are used to extend the anchor/resolution and CG of a context, respectively:

$$\vdash \forall_{n \in \omega}.\ ::_n = \lambda_{cx}\, \langle (\mathbf{a}\, c) \bullet_n x, \star_n\, (\mathbf{r}\, c), (\mathbf{p}\, c) \rangle$$
$$\vdash \forall_{n \in \omega}.+_n = \lambda_{cp}\, \langle (\mathbf{a}\, c), (\mathbf{r}\, c), (\mathbf{p}\, c)\ \mathsf{and}\ p \rangle$$

These axioms ensure that $::_n$ maps a specified entity to the 'next' DR and adds it to the resolution, while $+_n$ adds a specified proposition to the CG.

Lastly, the definedness check $\downarrow : (A \rightharpoonup B) \to A \to \mathrm{t}$ (written infix) tests whether a given partial function is defined for a given argument.

$$\vdash \downarrow = \lambda_{fx}.\mathsf{dom}\ f\ x$$

Where for a given partial function $f : A \rightharpoonup B$, $(\mathsf{dom}\ f)$ is the characteristic function of the subset of A that is the domain of f.

4.2 Context-Dependent Propositions, Updates, and Dynamic Propositions

Context-dependent propositions (CDPs), type k, are partial functions from contexts to propositions.

$$\mathrm{k} =_{\mathrm{def}} \mathrm{c} \rightharpoonup \mathrm{p}$$

The partiality of this type reflects the fact that an utterance is sensitive to the discourse context in which it is situated: not every context is suitable to yield an interpretation for a given utterance, only those where conditions like familiarity are met. The **empty CDP** $\top =_{\text{def}} \lambda_c.\mathsf{true}$ 'throws away' whatever context it is passed, returning the contentless proposition true (a necessary truth).

Updates, of type u, map CDPs to CDPs:

$$\mathrm{u} =_{\text{def}} \mathrm{k} \to \mathrm{k}$$

The type u is used to model the dynamic meanings of declarative sentences.

Dynamic properties are the dynamicized analogs of static properties, where static properties is defined as follows:

$$\mathrm{R}_0 =_{\text{def}} \mathrm{p}$$
$$\mathrm{R}_{(\textbf{suc}\ n)} =_{\text{def}} \mathrm{e} \to \mathrm{R}_n$$

Note that in particular, nullary properties are equated with propositions, and the arity of a static proposition is simply the number of arguments of type e it takes. The type hierarchy for dynamic properties is obtained from the one for static properties by replacing the base type p with the type u of updates, and replacing the argument type e with the type ω of DRs:

$$\mathrm{d}_0 =_{\text{def}} \mathrm{u}$$
$$\mathrm{d}_{(\textbf{suc}\ n)} =_{\text{def}} \omega \to \mathrm{d}_n$$

Again, note that nullary dynamic properties are just updates. Since d_1 is used most frequently, I write d to abbreviate the type d_1.

The **dynamicizer** functions $\textbf{dyn}_n$ map a static property of arity n to its dynamic counterpart:

$$\textbf{dyn}_0 =_{\text{def}} \lambda_{pkc}.p \ \mathsf{and}\ (k\ (c + p)) : \mathrm{R}_0 \to \mathrm{d}_0$$
$$\forall_{n:\omega}.\textbf{dyn}_{(\textbf{suc}\ n)} =_{\text{def}} \lambda_{Rm}.(\textbf{dyn}_n\ (R\ [m])) : \mathrm{R}_{(\textbf{suc}\ n)} \to \mathrm{d}_{(\textbf{suc}\ n)}$$

(Here, and is Pollard's (2008b) propositional conjunction.) I write static propositions in lowercase sans-serif (e.g. donkey) and their dynamic counterparts in smallcaps (e.g., DONKEY). Some examples of dynamicization:

$$\textsc{rain} =_{\text{def}} (\textbf{dyn}_0\ \mathsf{rain}) = \lambda_{kc}.\mathsf{rain}\ \mathsf{and}\ (k\ (c + \mathsf{rain}))$$
$$\textsc{donkey} =_{\text{def}} (\textbf{dyn}_1\ \mathsf{donkey}) = \lambda_{nkc}.(\mathsf{donkey}\ [n])\ \mathsf{and}\ (k\ (c + (\mathsf{donkey}\ [n])))$$
$$\textsc{own} =_{\text{def}} (\textbf{dyn}_2\ \mathsf{own}) = \lambda_{mnkc}.(\mathsf{own}\ [m]\ [n])\ \mathsf{and}\ (k\ (c + (\mathsf{own}\ [m]\ [n])))$$

These examples show the central feature of dynamic properties: the static proffered content is added to the discourse context that is used for evaluating subsequent updates.

Reducing a dynamic proposition to its static counterpart is handled by the **staticizer** function $\textbf{stat} : \mathrm{u} \to \mathrm{k}$, which is defined as follows:

$$\textbf{stat} =_{\text{def}} \lambda_u.u\ \top$$

The partiality of **stat** reflects the fact that a dynamic proposition can only be reduced to a static proposition in contexts that satisfy its presuppositions. To demonstrate, consider (for a hypothetical DR n) the staticizer applied to the dynamic proposition ($\textsc{donkey}\, n$):

$$\begin{aligned} n : \omega \vdash (\mathbf{stat}\ (\textsc{donkey}\ n)) &= (\lambda_{kc}.(\mathsf{donkey}\ [n])\ \mathsf{and}\ (k\ (c + (\mathsf{donkey}\ [n])))\ \top) \\ &= \lambda_c.((\mathsf{donkey}\ [n])\ \mathsf{and}\ (\top\ (c + (\mathsf{donkey}\ [n])))) \\ &= \lambda_c.(\mathsf{donkey}\ [n])\ \mathsf{and}\ \mathsf{true} \\ &\equiv \lambda_c.\mathsf{donkey}\ [n] \end{aligned}$$

where $\equiv$ denotes equivalence of CDPs.

4.3 Connectives and Quantifiers

The dynamic conjunction $\textsc{and} : \mathrm{u} \to \mathrm{u} \to \mathrm{u}$ essentially amounts to composition of updates, as it is for Muskens (1994, 1996):

$$\textsc{and} =_{\mathrm{def}} \lambda_{uvk}.u\ (v\ k) \tag{6}$$

The effect of dynamic conjunction is that the modifications to the discourse context made by the first conjunct are available to the second conjunct. For example (again with a hypothetical DR n), the conjunction ($\textsc{donkey} n$) $\textsc{and}$ ($\textsc{bray} n$) : u is treated as follows:

$$\begin{aligned} & n : \omega \vdash (\textsc{donkey}\ n)\ \textsc{and}\ (\textsc{bray}\ n) \\ & = \lambda_{kc}.(\textsc{donkey}\ n)\ ((\textsc{bray}\ n)\ k)\ c \\ & = \lambda_{kc}.(\lambda_{kc}(\mathsf{donkey}\ [n]\ \mathsf{and}\ k\ (c + \mathsf{donkey}\ [n]))\ \lambda_c(\mathsf{bray}\ [n]\ \mathsf{and}\ k\ (c + \mathsf{bray}\ [n])))\ c \\ & = \lambda_{kc}.(\mathsf{donkey}\ [n])\ \mathsf{and}\ (\mathsf{bray}\ [n])\ \mathsf{and}\ k\ (c + \mathsf{donkey}\ [n] + \mathsf{bray}\ [n]) \end{aligned}$$

(Here, $\textsc{donkey} = (\mathbf{dyn}_1\ \mathsf{donkey})$ and $\textsc{bray} = (\mathbf{dyn}_1\ \mathsf{bray})$.)

The dynamic existential quantifier $\textsc{exists} : \mathrm{d} \to \mathrm{u}$ introduces the 'next' DR:

$$\textsc{exists} =_{\mathrm{def}} \lambda_{Dkc}.\mathsf{exists}\ \lambda_x.D\ (\mathsf{next}\ c)\ k\ (c :: x) \tag{7}$$

As Equation 7 shows, the dynamic existential introduces a new DR mapped to an entity that is existentially bound at the propositional level. This new DR is added to the discourse context that is used by subsequent updates.

Dynamic negation limits the accessibility of DRs introduced within its scope, while negating the proffered content of its complement but propagating any presuppositions.

$$\textsc{not} =_{\mathrm{def}} \lambda_{uk}\lambda_{c\ |\ (u\ k)\downarrow c}.\mathbf{dyn}_0\ (\mathsf{not}\ (\mathbf{stat}\ u\ c))\ k\ c \tag{8}$$

The partiality condition $(u\ k) \downarrow c$ on the variable c is designed to require that any presuppositions of the complement of $\textsc{not}$ become presuppositions of the dynamic negation. This is best illustrated with an example, as follows for ($\textsc{donkey}\,n$).

$$
\begin{aligned}
n : \omega \vdash\ & (\textsc{not}\,(\textsc{donkey}\,n)) \\
&= \lambda_k \lambda_{c\,\mid\,((\textsc{donkey}\,n)\,k)\downarrow c}.\mathbf{dyn}_0\ (\mathsf{not}\ (\mathbf{stat}\ c\ (\textsc{donkey}\,n)))\ k\ c \\
&= \lambda_k \lambda_{c\,\mid\,((\textsc{donkey}\,n)\,k)\downarrow c}.(\mathsf{not}\ (\mathsf{donkey}\ [n]))\ \mathsf{and}\ (k\ (c + (\mathsf{not}\ (\mathsf{donkey}\ [n]))))
\end{aligned}
$$

Here, the (static) proffered content of ($\textsc{donkey}\,n$) is negated and this negation is added to the CG of the discourse context passed to the incoming update. As the condition on the variable c shows, ($\textsc{not}\,(\textsc{donkey}\,n)$) also requires of the incoming update that the DR n can be retrieved from the discourse context used to interpret it. Note that if the complement of NOT introduced any DRs, these new DRs would be unavailable to subsequent updates, as desired.

I also extend HDS with a dynamic disjunction, which will be used below to analyze a bathroom example like (D).

$$\textsc{or} =_{\mathrm{def}} \lambda_{uv}.\textsc{not}\,((\textsc{not}\,u)\ \textsc{and}\ (\textsc{not}\,v)) \tag{9}$$

This definition is analogous to the treatment of dynamic disjunction by Groenendijk and Stokhof (1991).

4.4 Dynamic Generalized Determiners

To model the English discourse meanings, several dynamic generalized determiners (all of type $\mathrm{d} \to \mathrm{d} \to \mathrm{u}$) are needed. First, the dynamic indefinite article A:

$$\textsc{a} =_{\mathrm{def}} \lambda_{DE}.\textsc{exists}\ \lambda_n.(D\,n)\ \textsc{and}\ (E\,n) \tag{10}$$

Similarly to the usual treatment of the generalized indefinite determiner in static semantics, the dynamic indefinite introduces a new DR and passes it to two conjoined dynamic properties. There is no need to state a novelty condition for indefinites, as Heim (1982) does, because the newly-introduced DR will always be as yet unused (see Equation 7, above).

I use the dynamic negation NOT and the definition of A in Equation 10 to build the dynamic generalized quantifier NO, which models the meaning of the generalized determiner *no*.

$$\textsc{no} =_{\mathrm{def}} \lambda_{DE}.\textsc{not}\,(\textsc{a}\ D\ E) \tag{11}$$

Along with AND and EXISTS, dynamic negation is also used to build the dynamic universal $\textsc{every} : \mathrm{d} \to \mathrm{d} \to \mathrm{u}$.

$$\textsc{every} =_{\mathrm{def}} \lambda_{DE}.\textsc{not}\,(\textsc{exists}\ \lambda_n.(D\,n)\ \textsc{and}\ (\textsc{not}\,(E\,n))) \tag{12}$$

This definition ensures that any DR that has the property specified in the restrictor D also has the property in the restrictor E. (Note that this definition of the dynamic universal yields only the so-called ‘strong’ readings for donkey sentences, but describing how the ‘weak’ readings arise is well beyond the scope of this paper. See e.g. Rooth (1987), Chierchia (1992), and Kanazawa (1994) for discussion.)

4.5 Extensions for Modeling Weak Familiarity

The dynamic generalized quantifier meaning $\textsc{it}_{\mathrm{s}} : \mathrm{d} \rightarrow \mathrm{u}$ uses the **def** operator to select the uniquely most salient nonhuman DR in the discourse context:

$$\textsc{it}_{\mathrm{s}} =_{\mathrm{def}} \lambda_{Dk}\lambda_{c \mid (\mathbf{def}\ \textsc{nonhuman})\downarrow c}.D\,(\mathbf{def}\ \textsc{nonhuman}\ c)\ k\ c \tag{13}$$

The difference between the definition of $\textsc{it}$ used here is that a partiality condition is used on the variable c to explicitly require that the context contain a DR with the property $\textsc{nonhuman}$. Since this is the strong version of Heim's familiarity condition (see Definition 1), I also add the subscript s. The ω-parameterized definiteness operator $\mathbf{def}_n : \mathrm{d} \rightarrow \mathrm{c} \rightharpoonup \omega_n$ is defined as follows to yield the most salient DR in the discourse context with a given dynamic property:

$$\mathbf{def}_n =_{\mathrm{def}} \lambda_{Dc}.\bigsqcup_{(\mathbf{r}\ c)} \lambda_{i\in\omega_n}.(\mathbf{p}\ c)\ \mathsf{entails}\ (\mathbf{stat}\ (D\ i)\ c) \tag{14}$$

where $\bigsqcup_{(\mathbf{r}\ c)}$ denotes the unique least upper bound operation on the resolution preorder of the context c. Note that $\mathbf{def}_n$ is partial, since for any given dynamic property D and context c, there may be no DR that is uniquely most salient among the DRs with the property D according to c's resolution.

To model weak familiarity for the pronoun *it*, I add a separate definition for *it* that is built on top of the strongly familiar version in Equation 13.

$$\textsc{it}_{\mathrm{w}} =_{\mathrm{def}} \lambda_{Dk}\lambda_{c \mid \varphi}.\mathsf{exists}\ \lambda_x.(\mathsf{nonhuman}\ x)\ \mathsf{and}\ \textsc{it}_{\mathrm{s}}\ D\ k\ (c :: x + \mathsf{nonhuman}\ x) \tag{15}$$

Here the condition φ on the context variable c is as follows:

$$\varphi = (\neg\,((\textsc{it}_{\mathrm{s}}\ D\ k)\downarrow c)) \wedge ((\mathbf{p}\ c)\ \mathsf{entails}\ (\mathsf{exists}\ \lambda_x.\mathsf{nonhuman}\ x))$$

In this weak version of *it*, the condition φ that describes which contexts it is defined for is broken into a conjunction.

The first conjunct $(\neg\,((\textsc{it}_{\mathrm{s}}\ D\ k)\downarrow c))$ ensures that the strongly familiar $\textsc{it}_{\mathrm{s}}$ is *not* defined. This is done in order to force the strong familiarity version to be used whenever an overt discourse referent is actually present in the context, rather than merely being entailed. This clause is important since $\textsc{it}_{\mathrm{w}}$ has the potential to introduce DRs. Without it, the weak familiarity *it* in Equation 15 could introduce DRs into a context when a suitable antecedent already existed.

The second conjunct expresses Roberts' (2003) notion of weak familiarity as given in Definition 2: the CG of the discourse context must entail that a nonhuman entity exists. The body of the abstract of $\textsc{it}_{\mathrm{w}}$ just invokes the strong version with a modified context that contains a newly introduced nonhuman DR. So the fundamental difference between the strong and weak versions of *it* are that one references a DR present in the context, and another introduces a new DR based on certain existential entailments of the CG.

I extend HDS to handle anaphora by possessive determiners by giving strong and weak versions of the pronoun *his*. The strong familiarity version of the dynamic generalized determiner $\textsc{his}_{\mathrm{s}}$ resembles the strong version of *it* in $\textsc{it}_{\mathrm{s}}$ in Equation 13.

$$\textsc{his}_{\mathrm{s}} =_{\mathrm{def}} \lambda_{DEk}\lambda_{c \mid \varphi}.E\ (\mathbf{def}\ \lambda_n((D\ n)\ \textsc{and}\ (\textsc{poss}\ n\ (\mathbf{def}\ \textsc{male}\ c)))\ c)\ k\ c \quad (16)$$

(Here, $\textsc{male} = (\mathbf{dyn}_1\ \mathsf{male})$ and $\textsc{poss} = (\mathbf{dyn}_2\ \mathsf{poss})$, where $\mathsf{poss} : \mathrm{R}_2$ is the two-place static relation of possession). For Equation 16, the condition on the context variable c is represented by

$$\varphi = ((\mathbf{def}\ D) \downarrow c) \wedge ((\mathbf{def}\ \textsc{male}) \downarrow c)$$

As the partiality condition φ shows, $\textsc{his}_{\mathrm{s}}$ is only defined for contexts where both a male DR and a DR with the property D are overtly accessible. This strong version of *his* takes two dynamic properties as arguments to return an update. It then applies the second dynamic property to the most salient DR with the property D that is possessed by the most salient male DR.

As for *it*, the weak familiarity version of *his* is defined in terms of the strong version $\textsc{his}_{\mathrm{s}}$.

$$\begin{aligned}&\textsc{his}_{\mathrm{w}} =_{\mathrm{def}} \lambda_{DEk}\lambda_{c \mid \varphi}.\mathsf{exists}\ \lambda_x.\\ &\quad((D\ (\mathsf{next}\ c)\ \textsc{and}\ (\textsc{poss}\ (\mathsf{next}\ c)\ [\mathbf{def}\ \textsc{male}\ c]))\ k\ (c :: x))\ \mathsf{and}\\ &\quad\textsc{his}_{\mathrm{s}}\ D\ E\ k\ (c :: x + (\mathbf{stat}\ (D\ (\mathsf{next}\ c)\ \textsc{and}\ (\textsc{poss}\ (\mathsf{next}\ c)\ [\mathbf{def}\ \textsc{male}\ c]))\ c :: x))\end{aligned}$$

In the case of $\textsc{his}_{\mathrm{w}}$, the definedness condition φ on c is

$$\begin{aligned}&\varphi = (\neg\ ((\textsc{his}_{\mathrm{s}}\ D\ E\ k) \downarrow c))\\ &\quad\wedge\ (\mathbf{p}\ c)\ \mathsf{entails}\ \mathsf{exists}\ \lambda_x.\mathbf{stat}\ (D\ (\mathsf{next}\ c)\ \textsc{and}\ \textsc{poss}\ (\mathsf{next}\ c)\ [\mathbf{def}\ \textsc{male}\ c])\ c :: x\end{aligned}$$

This version requires that the strong version of *his* is undefined in the discourse context it is passed. In particular, this implies that there is no uniquely most salient DR overtly represented in the context that bears the property D. It further requires that the CG entails the existence of an entity possessed by the uniquely most salient male DR, and that the possessed entity additionally has the property D. Similarly to the weak version of *it*, $\textsc{his}_{\mathrm{w}}$ invokes the strong *his* with a modified context that is extended with a DR bearing the weakly entailed property.

5 A Small Fragment Demonstrating Weak Familiarity

The weak familiarity version of *it* is best illustrated with an example.

(I) Either no donkey is walking around, or it's braying.

The example discourse in (I) is a simplification of bathroom examples of the kind in (D). But the principle is the same: no DR is accessible to serve as the anaphoric antecedent of the pronoun *it*. Noting that $\textsc{donkey} = (\mathbf{dyn}_1\ \mathsf{donkey})$,

$\textsc{walk} = (\mathbf{dyn}_1\ \mathsf{walk})$, and $\textsc{bray} = (\mathbf{dyn}_1\ \mathsf{bray})$, the dynamic meaning of (I) is as follows.

$$\begin{aligned}
&\vdash (\textsc{no donkey walk})\ \textsc{or}\ (\textsc{it}_\text{w}\ \textsc{bray})\\
&= (\textsc{not}\ (\textsc{a donkey walk}))\ \textsc{or}\ (\textsc{it}_\text{w}\ \textsc{bray})\\
&= \textsc{not}\ (\textsc{not}\ (\textsc{not}\ (\textsc{a donkey walk})))\ \textsc{and}\ (\textsc{not}\ (\textsc{it}_\text{w}\ \textsc{bray}))
\end{aligned}$$

Note that the left conjunct of the argument to the widest-scope negation is the dynamic double negation of *a donkey walks*:

$$\begin{aligned}
&\vdash \textsc{not}\ (\textsc{not}\ (\textsc{exists}\ \lambda_n.(\textsc{donkey}\ n)\ \textsc{and}\ (\textsc{walk}\ n)))\\
&\equiv \lambda_{kc}(\mathsf{not}\ (\mathsf{not}\ (\mathsf{exists}\ \lambda_x((\mathsf{donkey}\ x)\ \mathsf{and}\ (\mathsf{walk}\ x)))))\ \mathsf{and}\ (k\ (c + \varpi))
\end{aligned}$$

Here, the proposition contributed to the CG by the first conjunct is represented as

$$\varpi = \mathsf{not}\ (\mathsf{not}\ (\mathsf{exists}\ \lambda_x.(\mathsf{donkey}\ x)\ \mathsf{and}\ (\mathsf{walk}\ x)))$$

This proposition, along with the axiomatization of entailment for and and not in Equations 3, 4 and 5, together mean that the CG of the discourse context passed to the right disjunct entails the proposition $\mathsf{exists}\lambda_x.(\mathsf{donkey}x)\ \mathsf{and}\ (\mathsf{walk}x)$. This entailment therefore satisfies the requirement of the weak familiarity version of *it* that the CG must entail the existence of a nonhuman (with the assumption that any discourse context we would ever practically consider contains only nonhuman donkeys).

In view of this, $(\textsc{it}_\text{w}\ \textsc{bray})$ in the right disjunct reduces as follows, where the conditions on the context are suppressed for readability since they are satisfied.

$$\begin{aligned}
\vdash (\textsc{it}_\text{w}\ \textsc{bray}) &= \lambda_{kc}.\mathsf{exists}\ \lambda_x.(\mathsf{nonhuman}\ x)\ \mathsf{and}\ (\textsc{it}_\text{s}\ \textsc{bray}\ k\ \kappa)\\
&= \lambda_{kc}.\mathsf{exists}\ \lambda_x.(\mathsf{nonhuman}\ x)\ \mathsf{and}\ (\textsc{bray}\ (\mathbf{def}\ \textsc{nonhuman}\ \kappa)\ k\ \kappa)
\end{aligned}$$

Here $\kappa = c + \varpi :: x + (\mathsf{nonhuman}\ x)$ is the updated context produced by $\textsc{it}_\text{w}$ in the second conjunct, which in turn contains the proposition ϖ contributed by the first conjunct. Clearly, the conditions placed on the discourse context by $\textsc{it}_\text{s}$ are satisfied since the CG contains the information that the newly-introduced DR is nonhuman.

To demonstrate that this weak familiarity treatment extends to other definites besides pronouns, consider the following example, a simplification of (E).

(J)
1. Every man owns a donkey.
2. One man beats his donkey.

In (J), as in (E), the antecedent for *his donkey* is not overtly present in the discourse context, but is only inferable from entailments introduced by the first utterance.

Equation 17 shows an HDS analysis of the discourse in (J) that uses the weak familiarity variant of *his*.

$$\vdash \textsc{every man}\ \lambda_j.\textsc{a donkey}\ \lambda_i.\textsc{own}\ i\ j\ \textsc{and a man}\ \lambda_j.\textsc{his}_\text{w}\ \textsc{donkey}\ \lambda_i.\textsc{beat}\ i\ j \tag{17}$$

Starting with the analysis of the first utterance (J1) shows the entailment it introduces.

$$\begin{aligned}
&\vdash \textsc{every man}\ \lambda_j.\textsc{a donkey}\ \lambda_i.\textsc{own}\ i\ j\\
&= \textsc{not}\ (\textsc{exists}\ \lambda_n.(\textsc{man}\ n)\\
&\qquad \textsc{and}\ (\textsc{not}\ (\textsc{exists}\ \lambda_m.(\textsc{donkey}\ m)\ \textsc{and}\ \textsc{own}\ m\ n))\\
&\equiv \lambda_{kc}(\mathsf{not}\ (\mathsf{exists}\ \lambda_x((\mathsf{man}\ x)\\
&\qquad \mathsf{and}\ (\mathsf{not}\ (\mathsf{exists}\ \lambda_y((\mathsf{donkey}\ y)\ \mathsf{and}\ (\mathsf{own}\ y\ x)))))))\ \mathsf{and}\ (k\ (c+\varpi))
\end{aligned}$$

Here, $\textsc{man} = (\mathbf{dyn}_1\ \mathsf{man})$ and the variable ϖ represents the modifications to the discourse context made by the utterance in (J1):

$$\varpi = \mathsf{not}\ (\mathsf{exists}\ \lambda_x.(\mathsf{man}\ x)\ \mathsf{and}\ (\mathsf{not}\ (\mathsf{exists}\ \lambda_y.(\mathsf{donkey}\ y)\ \mathsf{and}\ (\mathsf{own}\ y\ x))))$$

This modified context, which is passed to the second utterance, is crucial because it contains an entailment that for each man, there exists some donkey that man owns. It is this entailment which allows the use of the weak familiarity version $\textsc{his}_\mathrm{w}$. Importantly, though the weak familiarity *his* is defined in the second utterance of (J), the strong version is not. This is because the discourse context $c+\varpi$ passed to (J2) does not contain a DR with the property of being a donkey owned by the uniquely most salient male. However, the existence of such an individual is entailed by the CG.

The analysis of (J2) is repeated in Equation 18.

$$\vdash \textsc{a man}\ \lambda_j.\textsc{his}_\mathrm{w}\ \textsc{donkey}\ \lambda_i.\textsc{beat}\ i\ j : \mathrm{u} \tag{18}$$

To show how the weak version of *his* allows the desired anaphoric reference, I start by reducing a subterm:

$$\begin{aligned}
&\vdash \lambda_j.\textsc{his}_\mathrm{w}\ \textsc{donkey}\ \lambda_i.\textsc{beat}\ i\ j\\
&= \lambda_{jkc}.\mathsf{exists}\ \lambda_y.(\mathsf{donkey}\ y)\ \mathsf{and}\ (\mathsf{poss}\ y\ [\mathbf{def}\ \textsc{male}\ c])\\
&\quad \mathsf{and}\ ((\textsc{his}_\mathrm{s}\ \textsc{donkey}\ \lambda_i.\textsc{beat}\ i\ j)\ k\ \kappa)\\
&= \lambda_{jkc}.\mathsf{exists}\ \lambda_y.(\mathsf{donkey}\ y)\ \mathsf{and}\ (\mathsf{poss}\ y\ [\mathbf{def}\ \textsc{male}\ c])\\
&\quad \mathsf{and}\ ((\textsc{beat}\ (\mathbf{def}\ \lambda_n(\textsc{donkey}\ n\ \textsc{and}\ \textsc{poss}\ n\ (\mathbf{def}\ \textsc{male}\ \kappa))\ \kappa)\ j)\ k\ \kappa)
\end{aligned}$$

where $\kappa = c :: y + (\mathsf{donkey}\ y)\ \mathsf{and}\ (\mathsf{poss}\ y\ [\mathbf{def}\ \textsc{male}\ c])$ represents the context as modified by $\textsc{his}_\mathrm{w}$ $\textsc{donkey}$, and the constraints placed on c by $\textsc{his}_\mathrm{w}$ are suppressed since they are satisfied. This reduction shows how the weak version of *his* interacts with the strong version: the DR j is required by $\textsc{his}_\mathrm{s}$ to beat the most salient donkey possessed by the most salient male, and $\textsc{his}_\mathrm{w}$ provides a context extended with an entity y that has exactly that property.

The reduction of the full term in Equation 18 is then as follows:

$$\begin{aligned}
&\vdash \textsc{a man}\ \lambda_j.\textsc{his}_\mathrm{w}\ \textsc{donkey}\ \lambda_i.\textsc{beat}\ i\ j\\
&= \textsc{exists}\ \lambda_n.(\textsc{man}\ n)\ \textsc{and}\ (\textsc{his}_\mathrm{w}\ \textsc{donkey}\ \lambda_i.\textsc{beat}\ i\ n)\\
&= \lambda_{kc}.\mathsf{exists}\ \lambda_x.(\mathsf{man}\ x)\ \mathsf{and}\ \mathsf{exists}\ \lambda_y.(\mathsf{donkey}\ y)\ \mathsf{and}\ (\mathsf{poss}\ y\ x)\ \mathsf{and}\ (\mathsf{beat}\ y\ x)\\
&\qquad \mathsf{and}\ (k\ (c+\varpi :: x + (\mathsf{man}\ x) :: y + (\mathsf{donkey}\ y)\ \mathsf{and}\ (\mathsf{poss}\ y\ x) + (\mathsf{beat}\ y\ x)))
\end{aligned}$$

Here, the proposition ϖ is the contribution to the CG made by the first utterance (as shown in the analysis of (J1), above) that permits the use of the weakly familiar version of *his*. Note that the first argument $\textsc{man}$ to the dynamic indefinite $\textsc{a}$ allows **def** in the second argument to select the most salient male DR in κ.

5.1 Overgeneration and Pragmatic Effects

Carl Pollard (personal communication) points out that the approach to weak familiarity I describe here seems to overgenerate. He gives (K) as an example.

(K) 1. Not every donkey brays.
2. # It's brown.

This discourse is clearly odd, because the pronoun seems to lack an anaphoric antecedent. Yet the theory I have presented thus far licenses (K) because an entailment is present that permits the weak familiarity version of *it* to be used in analyzing (K2). To see why, note that the following analysis of (K1) is permitted in HDS with the extensions I propose:

$$\begin{aligned}
&\vdash \textsc{not}\ (\textsc{every donkey bray}) \\
&= \textsc{not}\ (\textsc{not}\ (\textsc{exists}\ \lambda_n.(\textsc{donkey}\ n)\ \textsc{and}\ (\textsc{not}\ (\textsc{bray}\ n)))) \\
&\equiv \lambda_{kc}.(\mathsf{not}\ (\mathsf{not}\ (\mathsf{exists}\ \lambda_x.(\mathsf{donkey}\ x)\ \mathsf{and}\ (\mathsf{not}\ (\mathsf{bray}\ x))))) \ \mathsf{and}\ (k\ (c + \varpi))
\end{aligned}$$

Here, the updates made to the context are represented by

$$\varpi = \mathsf{not}\ (\mathsf{not}\ (\mathsf{exists}\ \lambda_x.(\mathsf{donkey}\ x)\ \mathsf{and}\ (\mathsf{not}\ (\mathsf{bray}\ x))))$$

Similarly as for the analysis of (I), above, this means that the resulting CG entails the proposition $\mathsf{exists}\,\lambda_x.(\mathsf{donkey}\,x)\ \mathsf{and}\ (\mathsf{not}\,(\mathsf{bray}\,x))$. It is this entailment that incorrectly allows the conditions imposed by $\textsc{it}_{\mathrm{w}}$ to be met for (K).

By way of illuminating this seeming overgeneration, consider the difference between the bathroom example (D), repeated here, and the discourses in (L).

(D) Either there's no bathroom$_i$ in this house, or it$_i$'s in a funny place.

(L) 1. Either there is no seat$_i$ in this theater that isn't taken, or ?it$_i$'s in the front row.
2. Either there are no seats in this theater that aren't taken, or #it's in the front row.

The discourses in (D) and (L) are only mild variants of one another, yet (D) is perfectly felicitous, (L1) is somewhat odd, and (L2) is infelicitous. A similar class of examples is due to Barbara Partee:

(M) 1. I lost ten marbles and found only nine of them.
2. $\left\{\begin{array}{r}\text{The missing marble} \\ \text{?It}\end{array}\right\}$ is probably under the sofa.

In (M), the missing marble can be anaphorically referenced by a sufficiently descriptive definite NP. But the descriptively impoverished *it* does not seem to suffice.

In attempting to explain away the apparent overgeneration in (K) in light of the difference in judgments reflected in these discourses, an appeal could be made to the **informational uniqueness** of Roberts (2003). Such a move would involve arguing that (K) is infelicitous because weak familiarity alone is not enough, and that definite NPs also presuppose that their antecedents are unique among the DRs in the context that are contextually entailed to have the relevant descriptive content. Since, in the discourses in (K) and (L), it is impossible to tell whether the existential entailment only applies to a single weakly familiar DR, attempting to anaphorically reference the weakly entailed DR with a uniqueness-presupposing pronoun like *it* results in a presupposition failure. Example (M) is similar, except that there are multiple possible antecedents for *it* that are overtly (and not merely weakly) familiar. So in (K), there could be multiple non-braying donkeys; in (L), more than one seat could be available; and in (M), *it* is insufficient to pick out the marble that is probably under the sofa.

For cases like (M), in which overtly familiar DRs are present, HDS correctly requires that a candidate antecedent be informationally unique (see the axiomatization of **def** in Equation 14). Ascribing the infelicity in (K) and (L) to informational uniqueness in an analogous way seems promising, but it leaves open one obvious question: what about the original bathroom example (D)? It does not seem reasonable to assume for any house that either it does not have a bathroom or it has a unique bathroom that is in a funny place. The house could easily have multiple bathrooms, all situated in odd locales. Yet, as mentioned above, the discourse in (D) is completely felicitous. In fact, it would seem strange in the extreme to follow up (D) with the question *Which bathroom are you referring to?*, possibly because (D) does not seem to be about a specific bathroom, just one that might be locatable.

I would argue that such apparent counterexamples to the informational uniqueness requirement are due to pragmatic effects. In the case of (D), a kind of pragmatically conditioned informational uniqueness is likely responsible for the felicity of the use of *it*. It is straightforward to imagine a discourse context for (D) in which the interlocutors are not so much interested in whether the house in question has a unique bathroom, but whether there is one that is usually designated for guests to use that can be located. Such a pragmatic explanation would be unavailable for examples like (L), because none of the (possibly multiple) available seats is in any sense expected by convention. Likewise, for (K), there is no designated non-braying donkey that can be picked out from all of the possible non-brayers.

However, I stop short of building Roberts' informational uniqueness into the lexical meaning of the weakly familiar versions of *it* and *his*. It seems preferable for the semantics to generate readings for felicitous discourses like (D), even if it means licensing some infelicitous examples like (L). My argument for this is simply that it is the job of the semantic theory to generate readings, and that pragmatic effects are beyond its scope. Since examples like (D), in which a pronoun is used even when there is no informational uniqueness, may well be at least as common as the examples like (K) where the lack of informational uniqueness is problematic, it does not seem appropriate to forcefully exclude one class of examples or another.

6 Conclusions and Remaining Issues

The extension to hyperintensional dynamic semantics I present in this paper represents the first attempt I am aware of to implement Roberts' (2003) weak familiarity in a dynamic framework. The resulting formal model lays out a fragment that deals with problematic examples of anaphora across inaccessible domains in a way that only mildly extends Heim's (1982) familiarity condition on definites. Rather than resort to tactics like scope extension, E-type pronouns, or presupposition accommodation, this account allows all definites to be construed by two similar mechanisms: anaphoric links are licensed by entailments of the common ground, and an overt DR is only required to be present in certain cases. The apparent cases of overgeneration of this approach seem less like true overgeneration and more like instances of pragmatic effects.

One formal issue that remains is that the dynamic meanings posited for *it* and *his* seem very similar. Each has two cases, one of which requires an overtly accessible DR in the discourse context with a certain property, the other merely requires the existence of an entity with that property. Since both function so similarly, it seems desirable to find a way to unify and simplify their definitions that clarifies this deep similarity between them. Another topic for future work is to explain the apparent similarity between certain aspects of the approach described here and the tactic for modeling proper names via presupposition accommodation given by de Groote and Lebedeva (2010).

Finally, the account I give here should be expanded to deal with problematic examples of the kind pointed out by Groenendijk and Stokhof (1991, (46)).

(N) Every player chooses a pawn. He puts it on square one.

In cases like these, there is neither an overly accessible DR available to serve as the anaphoric antecedent of *he*, nor is the existence of an antecedent entailed by the CG. It seems that weak familiarity, as formulated here, cannot capture this instance of anaphora across an inaccessible domain any more than strong familiarity can.

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