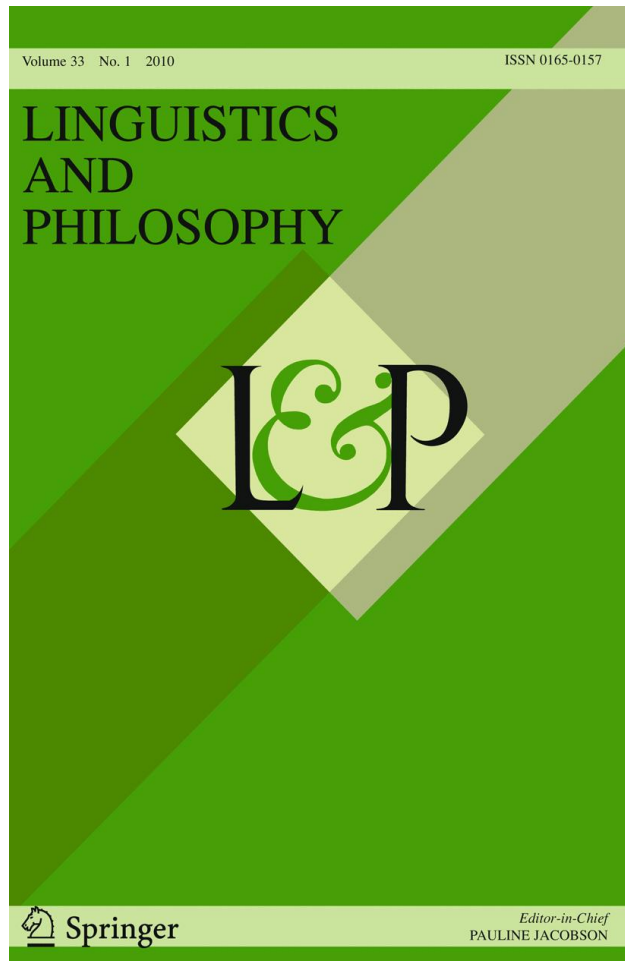


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Context dependence and implicit arguments in existentials

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Abstract This paper discusses the semantics of *bare existentials*, i.e. existentials in which nothing follows the post copular NP (e.g. *There are four sections*). While it has sometimes been recognized that the interpretation of such sentences depends in some way on context, the exact nature of the context dependence involved has not been properly understood. It is shown that the meaning of bare existentials involves a set-denoting implicit argument, and that the range of interpretations found with bare existentials is predictable from the general properties of implicit arguments. An explicit analysis within a dynamic setting is presented.

Keywords Existentials · Context dependence · Implicit arguments · Familiarity · Anaphora · Dynamic semantics

*We are the bees of the Invisible. We ceaselessly gather
the honey of the visible to store it in the
great golden hive of the Invisible.*

Rainer Maria Rilke, *Letter to Witold von Hulewicz*, 1925

1 Introduction

Bare existentials in English are existential sentences like those in (1), in which nothing follows the post-copular NP (the *pivot*).

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- (1) a. There is one God.
 b. There is no coffee.

What do bare existentials mean, and how should they be represented within a formal theory of meaning? Several authors have claimed that the semantics of bare existentials involves implicit content that is contextually determined (e.g. the work of Partee and Borschev 2002, 2004, 2006; Borschev and Partee 2001). For example, what exactly is asserted by (1b) is felt to depend on contextually resolving some information, perhaps supplying a “location”. However, as will become clear below, the nature of this presumed implicit content in existentials, even when recognized, has not been correctly characterized. Consequently, no adequate formal analysis of bare existentials, and of the role of context in determining their meaning, exists at present. This paper proposes such an analysis. Consideration of a fuller range of data than has been considered in the literature shows that bare existentials involve an *anaphoric implicit argument*, or what Fillmore (1986) calls a definite null anaphor. The semantic properties of anaphoric implicit arguments, specifically the different ways in which their value can be determined by context, have been famously discussed by Partee (1989), and have been analyzed within a dynamic framework in Condoravdi and Gawron (1996). I extend Condoravdi and Gawron’s analysis of anaphoric implicit arguments to existentials, resulting in an explicit semantics that overcomes deficiencies of previous accounts and increases empirical coverage.¹

The paper is organized as follows. In Sect. 2, the context dependence of bare existentials is discussed and data is presented showing that existentials involve an implicit anaphor. Existing analyses are shown to be incapable of modeling the data. Section 3 informally presents Condoravdi and Gawron’s analysis of context dependent predicates and their implicit arguments, and my proposal for extending this analysis to bare existentials. In Sect. 4, the proposal is formalized within a dynamic framework similar to the one used in Condoravdi and Gawron (1996), drawing on Dekker (1993) and Aloni (2000).

2 The context dependence of bare existentials

Barwise and Cooper’s (1981) analysis assigns to existentials the meaning in (2), relative to a model M with domain E .

- (2) $\llbracket \text{There be NP} \rrbracket_M = \llbracket NP \rrbracket_M(E)$.

¹ The analysis presented here is completely silent on the so-called “definiteness effect”. In particular, the semantics proposed does not exclude any noun phrases from occurring in existential constructions. In this respect this analysis is similar to many other semantic analyses in the literature, such as Barwise and Cooper (1981), Keenan (1987), Zucchi (1995), or Keenan (2003), none of which propose a semantics that blocks any NPs from occurring in the construction. These authors do attempt a *characterization* of the NPs they take to be blocked, but such a characterization is irrelevant to the concerns of this paper. For a more elaborate statement of my view of the relation between the definiteness effect and the semantics of existentials see Francez (2009).

An existential is true iff the universe of discourse is one of the sets in the denotation of the generalized quantifier denoted by the pivot. The analyses in Keenan (1987) and Zucchi (1995), while differing from Barwise and Cooper's in important respects, assign the same truth conditions to bare existentials. I refer to this line of analysis as *strong existentialism*, since it predicts that in any bare existential, the scope set for the quantifier denoted by the pivot is the domain of the model.

While this analysis might work well for examples such as (1a), it is obvious that strong existentialism is in general too strong. For example, the sentence in (3a) receives the analysis in (3b).

- (3) a. There's no coffee.
 b. $\llbracket \text{There is no coffee} \rrbracket = 1$ iff $E \in \lambda P_{\langle e,t \rangle} . P \cap \lambda x . \text{coffee}(x) = \emptyset$
 iff $E \cap \lambda x . \text{coffee}(x) = \emptyset$

If (3b) were the meaning of (3a), then the discourse in (4a) would be as infelicitous as the one in (4b), which it is not.²

- (4) a. There's no coffee but we can go get some down the block.
 b. #Coffee doesn't exist but we can go get some down the street.

Strong existentialism also generates wrong inference patterns. If (3b) were correct, then the inference in (5) would be valid, but in fact it is not.

- (5) There's no coffee \rightarrow There's no coffee at the store.

The source of these infelicities is obvious. The sentence in (3a) does not assert that there is no coffee in the universe of quantification, but merely that there is no coffee in the relevant context. A satisfactory analysis of bare existentials must incorporate context dependence in their semantics. The question is what exactly the contextual contribution is.

An immediate possibility is that what is missing from Barwise and Cooper's picture is just a run of the mill contextual domain restriction. If the pivot denotes a generalized quantifier, then it is only natural to expect that the quantification involved is contextually restricted, like most (if not all) quantification in natural language. Incorporating contextual domain restriction into the picture is trivial. The semantics in (2) can be replaced with (6).

- (6) $\llbracket \text{There is no coffee} \rrbracket = 1$ iff $E \in \lambda P_{\langle e,t \rangle} . P \cap \lambda x . \text{coffee}(x) \cap C = \emptyset$,
 where C is a contextually supplied set.

However, it is possible to show (see Francez 2009 for a full discussion) that what is involved in existentials is not contextual domain restriction because it is not the restriction set of the quantifier which is contextually determined. The evidence

² On the simplifying assumption that the extension of the predicate "exist" is the universe of quantification. This is a highly problematic assumption, but its problems do not effect the argument against strong existentialism.

comes from existentials with strong NPs in the pivot. Suppose that (7) is uttered in a conversation about the annual picnic of the fire department.

(7) There was every kind of food imaginable.

The semantics of (7) within the contextual domain restriction approach would be along the lines of (8).³

(8) $\llbracket \text{There was every kind of food imaginable} \rrbracket = 1$ iff
 $E \in \lambda P_{\langle e,t \rangle} . \{k | \text{imaginable-kind-of-food}(k) \ \& \ C(k)\} \subseteq P$ iff
 $\{k | \text{imaginable-kind-of-food}(k) \ \& \ C(k)\} \subseteq E$.

(8) asserts that the universe of quantification contains every kind of food imaginable within some contextually relevant set (e.g. every imaginable kind of food in the relevant picnic). But this assertion is trivially true, and would make (7) equivalent to the tautological (9). However, (7) is contingent, not tautological.

(9) Every kind of food imaginable that was at the picnic exists.

This shows that contextually restricting the quantifier denoted by the pivot does not solve the problem. If pivots denote generalized quantifiers, then the contextual contribution in existentials is not in their restriction, but in their *scope*.

Partee (2004 [1999]) attempts to merge the basic architecture of Barwise and Cooper's approach with the intuition that the scope set for the pivot quantifier is implicit and contextually resolved. Her proposal is that bare existentials involve "the existential generalization of a missing XP argument in a construction whose full form is ... there be NP XP". However, her discussion of this existential generalization involves some confusion. She claims that existential generalization of the XP is equivalent to resolving the scope for the pivot to the property *exist*, which characterizes the domain of quantification and which is taken to be coextensive with the property of self identity, $\lambda x[x = x]$. Thus, she assigns the three meanings in (10) to *there is/are* in the absence of an XP (cf. her (19a)), claiming that they are all equivalent. However, they clearly are not all equivalent.

(10) $\llbracket \text{there is/are} \rrbracket =$
 a. $\lambda P_{\langle e,t \rangle} [\exists Q_{\langle e,t \rangle} [\mathcal{P}(Q)]]$
 b. $\lambda P [\mathcal{P}(\lambda z[z = z])]$
 c. $\lambda P [\mathcal{P}(\text{exist})]$

The expressions in (10b) and (10c) are equivalent, and denote the set of GQs that contain the entire domain of quantification. This interpretation of bare existentials therefore simply reproduces strong existentialism. The expression in (10a), on the other hand, denotes something different, namely the set of non-empty GQs. This too cannot be the correct meaning, since if it were, then a bare existential *There be NP* would be true if the quantifier denoted by the NP is not empty. But this would make any existential with a coda entail the corresponding bare existential. This entailment does not intuitively go through in most cases. For example, (11b) does not seem to follow from (11a).

³ The exact semantics of this kind of existential is not self evident, but is irrelevant for the argument at hand.

- (11) a. There are two flowers in my office
 b. There are two flowers.

The entailment is very clearly *never* valid with non-monotone or downward monotone determiners, as shown in (12).

- (12) There are no monkeys in the Arctic \nrightarrow There are no monkeys.

Thus, bare existentials do not involve existential generalization over the scope of the quantifier denoted by the pivot.

The descriptive generalization at this point is that in a bare existential of the form *there be NP*, there is some information missing. The discussion above showed that this implicit information does not correspond to an existential generalization over the “location” where something is asserted to exist or not exist. What then is the missing information? The following quote from Borschev and Partee (2001, 22) indicates the right direction:

It is important that existence is always understood with respect to some LOCATION. An implicit LOCATION must be given by the context. This is usually “here” or “there”, “now” or “then”.

This indicates that the implicit location is usually **anaphoric**, rather than existentially quantified. Its value is determined by context in a way similar to nominal anaphora resolution.

Partee’s (1999) analysis in terms of existential generalization and the analysis implied by the quote above correspond, respectively, to the two types of *implicit arguments* identified by Fillmore (1986). Fillmore refers to implicit arguments that are interpreted existentially as *indefinite null anaphors*, and to ones that are interpreted anaphorically as *definite null anaphors*. The contrast is exemplified in (13).

- (13) a. I ate. (= I ate something)
 b. I noticed. (= I noticed this/that)

Fillmore’s typology of implicit arguments makes it clear where Partee’s (1999) analysis went wrong. It mistakenly analyzed bare existentials as involving an indefinite null anaphor. Thus, following Borschev and Partee’s intuition, my suggestion is that bare existentials involve a definite null anaphor, corresponding to the scope set for the pivot. So far, the only positive evidence I have presented in support of this suggestion was an intuitively appealing quote. However, much more can be said once the general nature of definite null anaphors is considered.

Partee (1989) identified three types of context to which anaphoric elements can be sensitive:

- External context of the utterance (deictic elements, indexicals)
- Discourse context (non-deictic pronouns)
- Internal linguistic context (pronouns on bound variable readings)

She shows that *context sensitive* predicates, i.e. predicates such as *local* or *win*, which can be construed as involving an anaphoric implicit argument, are sensitive to all three kinds of contexts. This is evident in the range of readings such implicit arguments can have, namely deictic, discourse anaphoric and bound variable readings. The three readings are exemplified in (14) for the context sensitive predicate *local*.⁴

- (14) a. **Deictic:** A local bar is selling cheap beer.
 b. **Discourse anaphoric:** We stayed two weeks in the village. A local bar was selling cheap beer.
 c. **Bound variable:** Every fan watched the game in a local bar.

On the deictic reading, (14a) is interpreted to assert that a bar local to the location of utterance is selling cheap beer. On the discourse anaphoric reading in (14b), the bar is understood to be local to the village mentioned in the first sentence. On the bound variable reading in (14c), each bar is local to the location of one of the fans.

Condoravdi and Gawron (1996) (henceforth CG) observe further that implicit anaphors show a property that contrasts definite descriptions and pronouns. Pronouns must refer back to a linguistic antecedent if there is one. Definite descriptions typically also refer back to something familiar in the discourse, but unlike pronouns, their familiar “antecedent” need not be a linguistic antecedent, but can be implied. This is exemplified in (15).

- (15) (= CG’s example (13))
 a. Every man who bet on the Superbowl won.
 b. = Every man who bet on the Superbowl won the bet.
 c. ≠ Every man who bet on the Superbowl won it.

In (15b), the NP *every man who bet on the Superbowl* implies, for each man, a bet that he placed. The definite description *the bet* is anaphoric to this bet, even though it is not explicitly mentioned in the preceding discourse. (16c) shows that this kind of anaphora is not possible for a pronoun: *it* must refer to the Superbowl, it cannot refer to the implied bets. (15a) shows that the implicit argument of *win* has the same range of interpretation as the definite description.⁵

⁴ Of course, none of these readings are *obligatory* for the relevant sentences.

⁵ This pattern should be expected to be invariant across languages. The following shows that it holds in Hebrew. (ii) and (iii) contrast in Hebrew in the same way that (15b) contrasts with (15c).

- (i) kol mi Se-hitarev al ha-misxak niceax.
 all who that-bet[3.m.sg.pst] on the-game win[3.m.sg.pst]
 Everyone who bet on the game won.
 (ii) kol mi Se-hitarev al ha-misxak niceax ba-hitarvut.
 all who that-bet[3.m.sg.pst] on the-game win[3.m.sg.pst] in.the-betting
 Every man who bet on the game won the bet.
 (iii) kol mi Se-hitarev al ha-misxak niceax bo.
 all who that-bet[3.m.sg.pst] on the-game win[3.m.sg.pst] in[3.m.sg]
 Every man who bet on the game won it.

These two observations generate two immediate predictions for the proposal that bare existentials involve an implicit anaphor. First, the three readings (deictic, discourse anaphoric, and bound variable) available to implicit arguments are expected to be available also for the implicit argument in bare existentials. Second, the implicit argument of a bare existential is expected to contrast with an overt pronoun in being able to pick up on an implied entity even in the presence of an overt potential antecedent.

Both of these predictions are borne out. The three readings available to the implicit argument of a bare existential are shown in (16).

- (16) a. There's no more coffee. (**Deictic**)
 b. We had to leave the village. There was no more coffee. (**Anaphoric**)
 c. Every tourist who visited a village abandoned it when there was no more coffee. (**Bound variable**)

The contrast between implicit arguments and pronouns is shown in (17)–(19). In each case, the over pronominal following the pivot cannot pick up on the implied “location” that the implicit argument of the bare existential picks up on.

- (17) a. Jacob fled to Egypt because there was a famine. (possible: famine in Canaan)
 b. Jacob fled to Egypt because there was a famine there. (necessary: famine in Egypt)
- (18) a. The Austro-Hungarian emperor travelled to Istanbul because there was a siege. (possible: siege in Vienna)
 b. The Austro-Hungarian emperor travelled to Istanbul because there was a siege there. (necessary: siege in Istanbul)
- (19) a. Everyone who attended the screening noticed that there was a lot of violence. (possible: violence in the movie)
 b. Everyone who attended the screening noticed that there was a lot of violence there. (necessary: violence at the screening)

Thus, a closer examination of the behavior of bare existentials in context shows that their implicit content is resolved in exactly the same way as is the content of sentences involving implicit anaphoric arguments of lexical predicates. A semantic analysis that models implicit anaphors in the latter context should therefore be naturally extendable to bare existentials.

Before moving on to discuss how implicit arguments might be analyzed, I briefly discuss McNally's analysis of existentials in terms of *instantiation* (McNally 1992, 1998), perhaps the strongest alternative in the literature to the strong existentialist analyses discussed above. McNally's theory of existentials is based on the following premises:

- (i) The main predicate in an existential, denoted by *there be*, is an intransitive predicate meaning roughly *is instantiated*.

- (ii) The single argument of this predicate, denoted by the pivot, is a property.
- (iii) An existential sentence is true iff the property expressed by the pivot is instantiated at some index.

Whether or not the assumptions in (i) and (ii) are correct is not directly relevant here (see Francez 2009 for discussion). What is important is that context enters this analysis through the relativization of instantiation to an *index*, as stated in (iii) above. The role of indices is not made explicit in McNally (1998), but is elaborated on in McNally (1992). There, an index is taken to be a triple $\langle w, t, l \rangle$ consisting of a world, a time, and a location. Since a bare existential is always interpreted relative to an index, the problems identified earlier with strong existentialism do not arise. For example, the sentence *there is no coffee* is true at an index $\langle w, t, l \rangle$ if and only if there is nothing instantiating the property of being coffee at $\langle w, t, l \rangle$. This of course entails nothing about the presence or availability of coffee relative to other indices. However, in order to make this analysis account for the range of data just observed, a much more elaborate theory of indices and index-shifting is required. Thus, the ultimate success of such a theory would depend on whether the properties it confers on indices to account for existentials are justifiable for indices in general. Developing such a theory and determining this issue is an interesting enterprise which requires further research and is left for a future occasion.

3 The analysis informally

The analysis of existentials I develop here is an extension on the analysis of anaphoric implicit arguments developed by CG. That analysis in turn is rooted in Heim's familiarity theory of definites (Heim 1982). CG's core intuition is that implicit arguments of predicates like *local* should be analyzed like definite descriptions, associated with a familiarity presupposition. This presupposition is modeled as a restriction on input contexts. For an utterance of a sentence with an occurrence of *local* to be felicitous, the context must entail, or be made to entail through accommodation, the existence of something that can be understood as the antecedent of the argument. Lexical predicates usually also associate a presupposition of descriptive content with their arguments. For example, in the case of *local*, the context must entail that the antecedent of the implicit argument is a location.

The different readings of implicit arguments correspond to the different ways in which the presuppositions associated with them can be satisfied by a context. Deictic readings arise when the anaphor anchors to an entity familiar as part of the utterance context. Discourse anaphoric readings arise when the familiarity presupposition is fulfilled by a previously introduced discourse referent, possibly an accommodated one. Bound variable readings arise when the presupposition is satisfied locally in the computation of the dynamic effect of a quantifier. For example, the dynamic effect of a quantificational NP like *every apple* is to trigger a series of alternative contexts, each of which introduces a discourse referent which stands for an apple. It is then checked, for each such context, whether that apple has some property or properties attributed to it by the rest of the sentence.

Extending this analysis to existentials requires some theoretical choices, as well as further elaboration of the nature of the implicit anaphors involved. First, with lexical predicates like *local*, it is clear what the implicit argument is an implicit argument of. This is less so in the case of bare existentials. Two options seem reasonable to me. The implicit argument can be an argument of the copula, or it can be an argument of the pivot NP. I will, without argument, take it to be an argument of the pivot. This is in line with the theory of existentials put forth in Francez (2009), where it is argued that pivots should be viewed as the main (semantic) predicates of an existential, which therefore involve an implicit *argument* rather than an implicit *predicate*. However, nothing in the current analysis depends on that theory being correct.

Second, and more importantly for current purposes, something more must be said about the content of the presumed implicit anaphor in existentials. As discussed in the previous section, what is “missing” in an existential can be thought of as the scope set for the pivot. The implicit anaphor is therefore set-denoting. For example, in (20), the set that is said not to contain windows in the second sentence is the set of parts of the building mentioned in the first sentence. This is indicated in the bracketed paraphrase.

(20) I hate this building. There are no windows. (\approx There are no windows *in it*).

The question now arises how the implicit set argument in an existential sentence to be represented. The simplest approach would seem to be to simply posit a set-denoting anaphor in the representation of an existential, and make the value of this variable a contextual parameter. In (20), it is perhaps not implausible to assume that in speaking of a building, the set of its constitutive parts becomes salient enough so as to be resolved as the value of the set variable. In terms of a dynamic theory of meaning, adopting this approach would be equivalent to allowing discourse referents to stand for sets as well as for individuals.

An alternative would be to make the semantics reflect more directly the fact that in order to determine the relevant set, two things need to be retrieved contextually: a familiar individual a , and a binary relation R . The implicit argument of an existential is then a kind of complex anaphor, the value of which is then determined to be the set of R -successors of a , the set of things bearing R to a , $\lambda x . R(a, x)$. In (20), for example, the familiar entity is the building mentioned in the first sentence, and the contextually determined relation is the part-of relation. Here I adopt this latter alternative, for reasons discussed below. This kind of complex anaphor is not unique to existentials. Such anaphors have independently been posited to account for contextual domain selection. An example is (21), from Heim (1991).

(21) Few classes were so bad that no student passed.

Here, the quantification over students is contextually restricted, and on the most natural reading, the set restricting *no student* varies with the quantification over classes. For any class considered, the restriction is to the set of students *in that class*. In von Stechow's (1995) representation of this sentence in (22), $f(x)$ is a function that

maps each class to the students in it. Thus, here too context supplies a salient individual (the relevant class) and a binary relation (the *member-of*, or perhaps *student-in*, relation).

(22) [FEW CLASSES x] [x is so bad that [NO STUDENT $f(x)$] passed].

The difference between the example in (21) and bare existential examples is that, in the latter, the complex anaphor contributes the *scope* rather than restriction of an NP quantifier. The need to distinguish the generator from the binary relation in the semantics is further demonstrated by examples in which two implicit arguments are present, sharing a single generator but different relations. This is exemplified in (23), also from Heim (1991).⁶

(23) Few classes $_x$ were so bad that no student $_{R_1,x}$ passed the exam $_{R_2,x}$

In this case, R_1 and R_2 are arguably distinct, with R_1 understood as the *member-of* relation, R_2 as the *part-of* relation. A similar example could be constructed with bare existentials, using coordinated pivots.

(24) I saw your apartment $_x$. There are no windows $_{R_1,x}$ and a lot of dust $_{R_2,x}$.

In this case, R_1 is again the constitutive-part relation \ll , whereas R_2 is the sublocation relation \subseteq^{loc} .

I take cases in which the implicit argument of the pivot is resolved to be the domain of quantification to be unproblematic. Presumably, the domain of quantification of the model (or perhaps of the world of evaluation) is always familiar in any context. One could think of such cases as involving a complex anaphor, analogous to the other cases, with the generator being the domain of the model (or world) and the binary relation being set membership.

My main motivation for positing a complex anaphor in existentials rather than a simple set variable is that it seems to me crucial to isolate, and distinguish between, the two contextual contributions that figure in determining the value of the implicit argument, namely the familiar entity, which I call the *generator*, and the binary relation. First, while the generator is anaphoric, the contextual relation is not. Furthermore, as will become formally clear below, isolating the anaphoric generator is crucial in accounting for the different readings of bare existentials, since these are direct consequences of the different ways in which context can supply an antecedent for this generator. This is particularly crucial in accounting for cases of bound variable readings such as (16c), where the generator is interpreted in a manner similar to a donkey pronoun. Second, the binary relation component seems to be subject to the generalization that its most prototypical values belong to a natural class of mereological part-whole relations: the subinterval relation \subseteq , the sublocation relation \subseteq^{loc} and the constitutive-part relation \ll . This has been the case with all of the examples cited so far. For example, in both the non-existential (21) and the

⁶ I thank a reviewer for pointing this example out to me.

existential embedded in (20), it is \ll . Thus, conflating the two components into a single set variable obscures the nature of the anaphora involved and leads to missed grammatical generalizations. To summarize, the implicit argument in an existential on the current proposal is an argument of the pivot NP and is a complex anaphor denoting a set constructed from an entity (the generator) and a binary relation. The generator is associated with a familiarity presupposition, and the different readings of bare existentials arise from different ways in which context can satisfy this presupposition.

In some cases, the pivot may also impose descriptive restrictions. For example, a pivot denoting an eventuality (e.g. *There was an accident*) requires the value of its implicit argument to be a set of times or, perhaps, of spatio-temporal regions. Other felicity conditions are also known to be relevant for the felicity of bare existentials. For example, at least in English, the generator of the implicit argument of a pivot cannot in general be animate, as shown in (25).

- (25) a. #I hate John. There's a bad temper.
b. #I remember John. There's a huge nose.

I conjecture that these sentences are blocked by synonymous *have*-sentences, and that this is due to a preference in English for realizing animate topics as subjects. Most likely, other constraints are also involved. Whether such constraints can, or should, be explained at the level of semantic granularity assumed here is not clear to me. In any case, a full exploration of such constraints must be deferred for further research.

4 A framework for implicit arguments

Condoravdi and Gawron (1996) present an analysis of implicit arguments couched in a dynamic semantics. They follow Heim (1982) in analyzing definite anaphors as involving familiarity presuppositions, which are in turn modeled as felicity conditions on successful information update. In this section, I first describe their analysis in a slightly modified way, using the developed in Aloni (2000), which in turn is based on the language MDPL developed in Dekker (1993). I show how this analysis derives the three readings of implicit arguments as arising from different ways in which a context can satisfy the presupposition associated with an anaphor. This framework is then extended to bare existentials and the data discussed in the previous section.

4.1 The formal system

The formal system I assume here is the one employed in Aloni (2000). Let \mathcal{L} be a first order predicate logic language with a sentential operator \diamond and a presupposition operator ∂ (which Aloni borrows from Beaver 2001). A model M for \mathcal{L} is a pair $\langle D, W \rangle$, where W is a non-empty set of interpretation functions (called possible worlds) assigning denotations to the non-logical constants of \mathcal{L} , and D is a non-empty set of individuals.

Information states: Following Heim (1982), an information state is a set of *possibilities*. Possibilities are pairs consisting of a possible world and an assignment of individuals to variables. If M is a model for \mathcal{L} , and V is the set of variables of \mathcal{L} , then the set S^M of information states based on M is defined as in Definition 1.

Definition 1 Information states

$$S^M = \bigcup_{X \subseteq V} \mathcal{P}(W \times D^X)$$

Within an information state, all the assignments in all possibilities have the same domain. For any assignment g , $\text{dom}(g)$ is the domain of g . Given a possibility $i = \langle w, g \rangle$, I write w_i for w and g_i for g . The domain of a possibility i is $\text{dom}(g_i)$.

Denotations for expressions of \mathcal{L} relative to a possibility i with some domain $X \subseteq V$ are given as in Definition 2.

Definition 2 Denotations

For any non-logical constant α , the denotation of α in i , $i(\alpha) = w_i(\alpha)$

For any variable x , if $x \in X$, the denotation of x in i , $i(x) = g_i(x)$.

$i(x)$ is undefined otherwise.

Utterances are made against a given information state, the input state. Generally, there are two ways in which an utterance might change the information state against which it is uttered. First, new variables can be introduced, resulting in a larger domain. Given two possibilities i, j , I write $i \leq_x j$ to say that $\text{dom}(g_i) \cup \{x\} = \text{dom}(g_j)$ and i, j agree on all values in $\text{dom}(g_i)$.

Second, factual information about the values of variables already in the domain of the input state may be changed, in that certain possibilities are lost. The possibilities that are not lost are said to survive. A possibility i survives in an (output) information state σ' iff there is a possibility in σ' that is the same as i except for, possibly, having a larger domain. An entire input state survives in an output state iff all the possibilities in the input state survive in the output state.

Definition 3 Survival

If σ and σ' are information states, and i a possibility in σ , then

(i) i survives in σ' , $i \prec \sigma'$, iff $\exists j \in \sigma' : w_i = w_j \ \& \ g_i \subseteq g_j$.

(ii) $\sigma \prec \sigma'$ iff $\forall i \in \sigma : i \prec \sigma'$.

Given these definitions it is possible to state the semantics of \mathcal{L} , as well as the notion of update. The semantics consists of clauses defining the context change potential of a sentence ϕ . The notation $\sigma[\phi]$ is used for the result of updating σ with ϕ . The basic clauses are given in Definition 5. I use t standardly as a metavariable for terms, i.e. individual variables and constants. The clause for existential quantification uses the notation $\sigma[x]$ for the extension of σ with x , defined in Definition 4.

Definition 4 Extension

For any possibility i , let $i[x/d] = \langle w_i, g_i \cup \langle x, d \rangle \rangle$. The extension of σ with x , $\sigma[x]$, is the set of all possibilities $i[x/d]$ such that $i \in \sigma$ and $x \notin \text{dom}(g_i)$ and $d \in D$.

$$\sigma[x] = \{i[x/d] : i \in \sigma \ \& \ x \notin \text{dom}(g_i) \ \& \ d \in D\}$$

Definition 5 Semantics

$$\sigma[R(t_1 \dots t_n)] = \{i \in \sigma \mid \langle i(t_1), \dots, i(t_n) \rangle \in i(R)\}$$

$$\sigma[\neg\phi] = \{i \in \sigma \mid \neg\exists\sigma'' : \sigma[\phi]\sigma'' \ \& \ i \prec \sigma''\}$$

$$\sigma[\phi \wedge \psi] = \sigma[\phi][\psi]$$

$$\sigma[\exists x\phi] = \sigma[x][\phi]$$

For sentences involving quantificational determiners such as *every* and *most*, I adopt a regimentation like that defined in Dekker (1993), using the standard interpretation of determiners as relations between sets, albeit sets of assignments rather than of individuals.

(26) **Quantificational determiners:** If Q is a quantifiers symbol expressing a relation Q between sets, then

$$\sigma[Qx(\phi)(\psi)] = \{i \in \sigma : Q(\{j : i \leq_x j \ \& \ j \prec \sigma[x][\phi]\}, \{j : j \prec \sigma[x][\phi][\psi]\})\}$$

This concludes the exposition of (the relevant aspects of) the formal system. Next, I illustrate CG's analysis of deictic, discourse anaphoric, and bound variable readings for the context-dependent predicate *local* in this system.

4.1.1 Deictic readings

A deictic reading of an implicit argument is one in which the context it anchors to is the context of utterance. Following Kaplan (1989), a context of utterance is taken to involve what CG call *contextual roles* such as the speaker of the utterance, the location of utterance, etc. In uttering (27), the speaker can be asserting that a bar local to the location of utterance is selling cheap beer.

(27) A local₁ bar is selling cheap beer.

As CG show, deictic readings involve indexicality. Once the implicit argument receives a contextual role as its value, that value does not change in the scope of intensional operators. The details of CG's analysis of indexicality are not important here. What is important is that any sentence requires for felicity that the input context contain variables, the values of which are the contextual roles of the utterance context. Let loc_c be a designated discourse marker, the value of which is, for any context, the location of utterance. The meaning of (27) is represented as in (28b), assuming the translation of (27) into \mathcal{L} in (28a).

(28) a. $\exists x(\text{bar}(x) \ \& \ \text{local}(x, loc_c) \ \& \ \text{sell-cheap-beer}(x))$

b. $\sigma[\exists x(\text{bar}(x) \ \& \ \text{local}(x, loc_c) \ \& \ \text{sell-cheap-beer}(x))] =$
 $\{i \in \sigma[x] : g_i(x) \in w_i(\text{bar}) \ \& \ \langle g_i(x), g_i(loc_c) \rangle \in w_i(\text{local}) \ \&$
 $g_i(x) \in w_i(\text{sell-cheap-beer})\}$

(28b) says that the result of updating a context with (27) introduces a variable x which is said to be a bar and that this bar stands in the *local* relation to the location of utterance loc_c and that the bar sells cheap beer. Crucially, this update is only

defined if the discourse referent loc_c is familiar, i.e. is in the domain of the input context. This is always the case since loc_c is defined for any context in which something is uttered. Thus the deictic reading is always available.

4.1.2 Discourse anaphoric reading

The discourse anaphoric reading of an implicit argument arises when the familiarity requirement is filled by previous discourse. An example of a discourse anaphoric reading is given in (29).

(29) We spent the evening in Kreuzberg. A local bar was selling cheap beer.

Here, on the relevant reading, the implicit argument of *local* is simply anaphoric to its antecedent, *Kreuzberg*, introduced into the context in the immediately preceding discourse. This reading is represented in (30), assuming that the input context is the one resulting from an utterance of the first sentence in (29). Proper names are here taken to be interpreted as constant discourse referents in the sense of Muskens (1996), i.e. variables that are assigned the same value by all assignments. They are represented by boldface letters.

$$(30) \quad \sigma[\exists x(\text{bar}(x) \ \& \ \text{local}(x, \mathbf{k}) \ \& \ \text{sell-cheap-beer}(x))] = \\ \{i \in \sigma[x] : g_i(x) \in w_i(\text{bar}) \ \& \ \langle g_i(x), \mathbf{k} \rangle \in w_i(\text{local}) \ \& \ g_i(x) \in w_i \\ (\text{sell-cheap-beer})\}$$

The antecedent of an implicit argument need not be overt as in (29), it can be inferred, as in (31).

(31) A reporter_{*x*} got drunk last night. A local_{*l*} bar_{*y*} was selling cheap beer.

In this case, the location that plays the role of antecedent for the argument of *local* is the location associated with the reporter mentioned in the previous sentence. CG handle such cases by accommodation. The inferred antecedent is accommodated into the input context. The relevant notion of accommodation is the essentially standard one in (32).⁷

(32) **Ordinary accommodation** (Condoravdi and Gawron 1996, p. 15):
The information necessary to satisfy the familiarity conditions of a definite NP may be accommodated to a state σ , yielding a new state σ' , by relating the definite's discourse marker through some relation to a discourse marker in the domain of σ .

Thus, given a state σ , discourse referent x in its domain, and relation R , a new state $Accom(\sigma, R, x, y)$ is created by relating x through R to the accommodated referent y . This is defined in (33).

⁷ As CG point out, this definition is almost certainly too simple to serve as a full theory of accommodation. However, it suffices for present purposes.

$$(33) \quad Accom(\sigma, R, x, y) = \{i \in \sigma[y] : \langle g_i(x), g_i(y) \rangle \in w_i(R)\}$$

(34) shows the translation of the second sentence in (31) into \mathcal{L} . (35) shows the interpretation of (31), assuming that the input context σ is the result of updating a context with the first sentence in (31), and

$$(34) \quad \exists y(\text{bar}(y) \ \& \ \text{local}(y, l) \ \& \ \text{sell-cheap-beer}(y))$$

(35) **Discourse anaphoric reading:**

$$\begin{aligned} \sigma \llbracket \text{A local}_l \text{ bar}_y \text{ is selling cheap beer} \rrbracket = \\ \{i \in Accom(\sigma, \text{location-of}, x, l)[y] : g_i(y) \in \text{bar}(w_i) \ \& \ \langle g_i(y), g_i(l) \rangle \\ \in w_i(\text{local}) \ \& \ g_i(y) \in w_i(\text{sell-cheap-beer})\} \end{aligned}$$

The discourse marker x is already present in the domain of the input context σ because it was introduced when the first sentence in (31) was uttered. The state $Accom(\sigma, \text{location-of}, l, x)$ is therefore defined. (35) says that the result of updating σ with the sentence *A local bar was selling cheap beer* introduces a new referent y which is said to be a bar whose location is local to the location of x .

4.1.3 Bound variable readings

The bound variable interpretation of implicit arguments comes about when their value is determined relative to a set of information states brought about by a quantificational expression. An example is given in (36).

$$(36) \quad \text{Every fan}_x \text{ watched the game}_y \text{ in a local}_l \text{ bar}_z.$$

In (36) the value of the implicit argument of the predicate *local* varies with the quantification over fans. (37) shows the translation of (36) into \mathcal{L} .

$$(37) \quad \text{every } x(\text{fan}(x))(\exists z[\text{game}(y) \ \& \ \text{bar}(z) \ \& \ \text{watch-in}(x, y, z) \ \& \ \text{local}(z, l)])$$

The interpretation of (36) is then as in (38).

$$\begin{aligned} (38) \quad \sigma \llbracket \text{Every fan}_x \text{ watched the game}_y \text{ in a local}_z \text{ bar}_y \rrbracket = \\ \{i \in \sigma : \text{every}(\{j : i \leq_x j \ \& \ j \prec \sigma[x][\text{fan}(x)]\}, \\ \{j : j \prec \sigma'[\exists z[\text{game}(y) \ \& \ \text{bar}(z) \ \& \ \text{watch-in}(x, y, z) \ \& \ \text{local}(z, l)]]\})\} \\ \text{where } \sigma' = Accom(\sigma[x][\text{fan}(x)], \text{location-of}, x, l) = \\ \{i \in \sigma : \text{every}(\{j : i \leq_x j \ \& \ j \prec \sigma[x][\text{fan}(x)]\}, \\ \{j : j \prec \sigma'[z][\text{game}(y) \ \& \ \text{bar}(z) \ \& \ \text{watch-in}(x, y, z) \ \& \ \text{local}(z, l)]]\})\} \end{aligned}$$

For each fan, a referent corresponding to his or her location is accommodated as part of the input context for the calculation of the information that the relevant fan watched the game at a local bar. The bound variable reading results when this accommodated referent serves as the value of the implicit argument of *local*. Thus,

the presupposition associated with the implicit argument, i.e. the condition that it be familiar, is satisfied in the “local” context.

4.2 Extension to bare existentials

As discussed in the previous section, the context sensitivity of bare existentials is of a somewhat different sort from that of predicates like *local*. In a bare existential, what is implicit is not the argument of any lexical predicate, but rather the scope set for the quantifier in the pivot, i.e. a set that is said to contain (or not contain) the things over which the pivot quantifies. This set was shown to be “constructed” from a generator and a binary relation. The generator is associated with a familiarity presupposition, and possibly with presuppositions of descriptive content as well. The parallelism between existentials and context sensitive lexical predicates arises because the presuppositions associated with the implicit argument in the latter case can be satisfied in the same ways as those associated with the generator. The following shows how the relevant readings are derived in the framework just described.

4.2.1 Deictic reading

The deictic reading is exemplified in (39). On the relevant reading, (39) is understood to assert that there are four bedrooms in the location of utterance. Thus, in this case, the implicit generator of the scope set for the quantifier in the pivot is loc_e , the location of utterance, and the binary relation involved is the *location-of* relation. The scope set itself is, therefore, the set of things located in the location of utterance. I am assuming here that the generator is an implicit argument of the entire pivot NP, represented as a superscripted index on that NP.

(39) There are four bedrooms _{x^l} .

The translation of (39) into \mathcal{L} is given in (40), where R is a binary relation variable the value of which must be inferred from context. The interpretation of (39) is given in (41).

(40) **four** $x(\text{bedroom}(x))(R(x, l))$

(41) $\sigma[\text{four } x(\text{bedroom}(x))(R(x, l))] = \{i \in \sigma : \text{four}(\{j : i \leq_x j \ \& \ j \prec \sigma[x][\text{bedroom}(x)]\}, \{j : j \prec \sigma[x][\text{bedroom}(x)][\text{location-of}(x, l)]\})\}$

This interpretation (i.e. the function $\sigma[\text{four } x(\text{bedroom}(x))(R(x, l))]$) is only defined if the discourse referent l is familiar. The deictic reading arises when the value of l is loc_e , which is one of the contextual roles available in any context of utterance.

4.2.2 Discourse anaphoric reading

The discourse anaphoric reading of bare existentials is exemplified in (42).

(42) I saw an apartment _{x} . There were four bedrooms _{y^x} .

Here, the bare existential in the second sentence is understood to assert what integral parts the apartment mentioned in the first sentence contains. The implicit generator referent l is resolved to be the apartment that is the value of the referent x introduced by the first sentence in (42). The binary relation is resolved to be the part-whole relation \ll , and the scope set for the pivot *four bedrooms* is resolved to be the set of things that stand in a part-whole relation to the apartment mentioned. The interpretation of the bare existential in (42) is thus as in (43). The input context σ is taken to be the information state resulting from updating with the first sentence in (42).

$$(43) \quad \sigma[\mathbf{four} \ y(\text{bedroom}(y))(R(y, x))] = \{i \in \sigma : \mathbf{four}(\{j : i \leq_y j \ \& \ j \prec \sigma[y][\text{bedroom}(y)]\}, \{j : j \prec \sigma[y][\text{bedroom}(y)]\ll(y, x)\})\}$$

The function $\sigma[\mathbf{four} \ y(\text{bedroom}(y))(R(y, x))]$ is only defined if $x \in \text{dom}(\sigma)$, i.e. if the familiarity presupposition associated with the implicit generator is satisfied by the input context. In this case, the presupposition is satisfied because the referent x has been introduced in the previous sentence.

4.2.3 Bound variable reading

The bound variable reading is exemplified in (44).

$$(44) \quad \text{Every tourist}_x \text{ who rented a room}_y \text{ thought there was a private bath}_z^y.$$

This sentence is naturally interpreted as saying that every tourist who rented a room thought there was a private bath *in the room they rented*. In other words, the generator for the scope set of the pivot varies with the quantification over tourists. The relevant binary relation is again the part-whole relation \ll . The translation of (44) into \mathcal{L} is given in (45).

$$(45) \quad \mathbf{every} \ x(\text{tourist}(x) \ \& \ \exists y[\text{room}(y) \ \& \ \text{rented}(x, y)]) \\ (\text{thought}(x, \exists z[\text{private-bath}(z) \ \& \ \ll(y, z)]))$$

I assume here the standard semantics for the attitude verb *think* according to which it quantifies over the doxastic possibilities entertained by an agent. To state this semantics it is useful to define the notion of *support*. An information state σ is said to support a sentence ϕ when updating σ with ϕ yields an information state in which σ survives, i.e. in which all the possibilities in σ survive.

Definition 6 Support

If σ is a state and ϕ is a formula of \mathcal{L} , then σ supports ϕ , $\sigma \models \phi$, iff $\exists \sigma' : \sigma[\phi] = \sigma' \ \& \ \sigma \prec \sigma'$

For any individual a and possibility $i = \langle w, g \rangle$, let $\text{dox}_{a,i}$ represent the belief state of a in i , an information state consisting of those possibilities compatible with all of a 's

beliefs in w , and which has at least the same domain as g .⁸ The semantics for *think* is then given in (46).

$$(46) \quad \sigma[\text{think}(x, \phi)] = \{j \in \sigma : \text{dox}_{g_j(x),j} \models \phi\}$$

The meaning of (44) can then be represented as in (47). The familiarity presupposition associated with the generator, the discourse referent y , is satisfied because this referent is introduced within the alternative possibilities invoked by the quantification over tourists who rented a room.

$$(47) \quad \sigma[\text{every } x(\text{tourist}(x) \ \& \ \exists y[\text{room}(y) \ \& \ \text{rented}(x, y)]) \\ (\text{think}(x, \exists z[\text{private-bath}(z) \ \& \ \ll(y, z)]))] = \\ \{i \in \sigma \mid \text{every}(\{j \in \sigma : i \leq_x j \ \& \ j \prec \sigma[x][\text{tourist}(x)][y][\text{room}(y) \ \& \ \text{rent}(x, y)]\}, \\ j \in \sigma : j \prec \sigma[x][\text{tourist}(x)][y][\text{room}(y) \ \& \ \text{rent}(x, y)] \\ [\text{think}(x, \exists z[\text{private-bath}(z) \ \& \ \ll(z, y)])]\}$$

To conclude, this section has shown how the three readings available to bare existentials can be captured within a general dynamic theory of (definite) implicit arguments. The core of the theory is that the different readings correspond to different ways in which a context can satisfy familiarity presuppositions associated with an argument.

5 Summary and conclusions

This paper started with the question of what the meaning of *bare existentials* is. While some authors have stressed that an adequate answer must introduce context dependence in the interpretation of bare existentials, the nature of the relevant contextual contribution has been little studied and poorly understood. In line with ideas of Borschev and Partee's, I argued that bare existentials involve an anaphoric implicit argument, which denotes a set and functions as the scope set for the quantifier introduced by the post-copular NP. The implicit argument in bare existentials was shown to have all the properties associated with the implicit definite null anaphors found with context sensitive predicates like *local*. I argued further that the implicit argument of existentials is a complex anaphor constructed from an individual (called the generator) and a binary relation. Resolving its value requires context to contribute a familiar antecedent for the generator and a salient binary

⁸ The requirement that the possibilities in the state dox_{a_i} have the same domain as g_i is a simplifying assumption. In belief reports, there is in fact no requirement that the discourse referent introduced in the belief ascription be defined for or familiar to the epistemic agent. For example, a sentence like (i), on its *de re* reading, does not presuppose that John is familiar with the queen of Holland, and hence does not require the discourse referent used by the ascriber to be defined for John.

(i) John thinks the queen of Holland is tall.

It *does* presuppose that John believes about someone that they are tall, and that that person is the value of the discourse referent associated for the ascriber with the expression *the queen of Holland*. For current purposes, this simplification is useful and harmless.

relation. The value of the complex anaphor is the set of entities that bear the binary relation to the generator.

The picture that emerges of the semantics of existentials is thus more intricate than has been recognized. I proposed an analysis of the role of context in determining the content of bare existentials within dynamic semantics based on the analysis of anaphoric implicit arguments in Condoravdi and Gawron (1996). This analysis derives the properties of implicit arguments, including those found in bare existentials, within a uniform, non-representational theory of context.

Several issues are left open. First, the range of binary relations available contextually seems to be highly limited, and there are also robust restrictions on what entities can serve as antecedents for the generator in the implicit argument of bare existentials. These restrictions are manifest in cases where following up an utterance with a bare existential is impossible. Whether or not the nature of such restrictions can be elucidated at the level of formal semantics is not obvious and remains to be seen. Second, the question arises how the proposed analysis should be integrated with an analysis of existentials that are not bare, i.e. existentials with explicit codas. Francez (2009) provides an explicit analysis of codas within a static setting. Incorporating that analysis into the dynamic setting used here is left for future research.

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