

## Donkeys under Discussion\*

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**Abstract** Donkey sentences have existential and universal readings, but they are not often perceived as ambiguous. We extend the pragmatic theory of non-maximality in plural definites by Križ (2016) to explain how hearers use Questions under Discussion to fix the interpretation of donkey sentences in context. We propose that the denotations of such sentences involve truth-value gaps — in certain scenarios the sentences are neither true nor false — and demonstrate that Križ’s pragmatic theory fills these gaps to generate the standard judgments of the literature. Building on Muskens’s (1996) Compositional Discourse Representation Theory and on ideas from supervaluation semantics, we define a general schema for dynamic quantification that delivers the required truth-value gaps. Given the independently motivated pragmatic theory of Križ 2016, we argue that mixed readings of donkey sentences require neither plural information states, contra Brasoveanu 2008, 2010, nor error states, contra Champollion 2016, nor singular donkey pronouns with plural referents, contra Krifka 1996, Yoon 1996. We also show that the pragmatic account improves over alternatives like Kanazawa 1994 that attribute the readings of donkey sentences to the monotonicity properties of the embedding quantifier.

**Keywords:** donkey sentences, dynamic semantics, homogeneity, non-maximality, Question under Discussion, semantics/pragmatics interface, trivalence, truth-value gaps, weak/strong (existential/universal) ambiguity

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## 1 Introduction

It is an old observation that some donkey pronouns seem to be understood as having existential force and others as having universal force. The following pair is adapted from Yoon 1996:

- (1) Usually, if a man has a garage with a window, . . .
- a. he keeps it open while he is away.
  - b. he keeps it closed while he is away.

Setting aside interpretations in which the donkey pronoun *it* is not anaphoric to *a window*, on the most plausible reading of (1a) this pronoun could be paraphrased as *one of the windows in his garage* (except that there is no implication that the garage actually has more than one window). This is sometimes referred to as a weak or existential interpretation; following Chierchia (1992, 1995), we will call it the existential reading or  $\exists$ -reading. As for (1b), on its most plausible reading the meaning of the pronoun is paraphraseable as *all of the windows in his garage*. This is the strong or universal interpretation, and we will refer to it as the universal reading or  $\forall$ -reading.<sup>1</sup>

Yoon 1994, 1996 and Krifka 1996 link this behavior of donkey pronouns to maximal and non-maximal interpretations of plural definites. Imagine the following sentences, adapted from Krifka 1996, uttered among bank robbers in a situation where the local bank has a safe that is accessible through any one of three doors.

- (2) (I wasn't/was able to reach the safe because . . .)
- a. The doors are closed.
  - b. The doors are open.

As Krifka observes, in the situation just described, sentence (2a) expresses the fact that all of the doors are closed (a *maximal* interpretation), while sentence (2b) expresses the fact that at least some of the doors are open (a *non-maximal* interpretation). These two readings naturally correspond to the  $\forall$ -reading and to the  $\exists$ -reading of donkey pronouns. On the basis of this kind of similarity, Yoon and Krifka develop a sum-based analysis of donkey sentences, in which the pronoun *it* in (1) is analyzed as referring to the mereological sum of all the windows in the garage in question. It is interpreted as number-neutral; that is, it does not presuppose that there is more than one window or door. Apart from this, it is essentially synonymous — *mutatis mutandis* — with the plural definite *the doors* in (2).

<sup>1</sup> As Kanazawa 1994 notes, the weak/strong terminology is misleading, because when the embedding determiner is downward monotone in its nuclear scope, as in the case of *no*, the weak reading is the logically stronger of the two.

However, Kanazawa 2001 convincingly shows that singular donkey pronouns, unlike plural definites, cannot refer to sums. For example, singular donkey pronouns are incompatible with collective predication, while plural definites are compatible:

- (3) a. Every donkey-owner gathers his donkeys at night.  
b. \*Every farmer who owns a donkey gathers it at night.

This poses a challenge for analyses of the  $\exists/\forall$  dichotomy that try to reduce the behavior of singular donkey pronouns to that of plural definite descriptions.

The goal of this paper is to develop a theory that meets this challenge but succeeds at predicting how context disambiguates donkey sentences embedded by determiners, and to show that the apparent complexity of the  $\exists/\forall$  dichotomy follows from the interaction of two relatively simple independently motivated formal systems: a pragmatic account of how context disambiguates plural definites and donkey sentences, and a lean dynamic semantics that delivers truth-value gaps for the pragmatics to fill. To avoid the problems that arise from interpreting singular pronouns as referring to sums, we locate the parallel between donkey pronouns and plural definites in the pragmatics rather than in the semantics. We claim that the denotation of a donkey sentence does not generally draw a clean line between the region of logical space where it is true and the region where it is false; rather, those two regions are buffered by possibilities that get apportioned in different ways depending on the pragmatics. We assume that these truth-value gaps are filled at the sentence level, not at the level of plural definites or donkey pronouns, following the implementation of trivalence resolution developed in Križ 2016 for plural definites. In other words, donkey pronouns are not similar to plural definites; it is donkey sentences as a whole that are similar to sentences with plural definites.<sup>2</sup>

The paper is structured as follows: Section 2 highlights the pragmatic nature of the  $\exists/\forall$  dichotomy by focusing on the role of context in disambiguating it. Section 3 is a brief summary of the theory developed by Križ (2016) for plural definites. Section 4 applies this theory to donkey sentences and develops the pragmatic part of our account. Section 5 presents a fragment that delivers truth-value gaps as needed by building on standard compositional approaches to dynamic semantics (in particular, Muskens 1995, 1996). Section 6 compares the present account with previous work, specifically Kanazawa 1994, Barker 1996, Geurts 2002, Brasoveanu 2008, 2010, and a precursor of the present work, Champollion 2016. Section 7 concludes by highlighting some of the benefits of the account developed here and by pointing out open questions and suggesting new avenues of research.

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<sup>2</sup> More precisely, the similarity is not at the level of noun phrases but at the level of clauses that correspond to donkey sentences, as in *If every student who took a class from me liked it, I will get a bonus*. We set embedded donkey sentences aside for the purposes of this paper.

## 2 The $\exists/\forall$ dichotomy and the role of context

It is easy to judge the truth of the donkey sentence in (4) if no man treats any two donkeys differently. In such scenarios, if every man beats every donkey he owns, it is clearly true; if instead some man beats none of the donkeys he owns, it is clearly false.

- (4) Every man who owns a donkey beats it.

Truth conditions become more difficult to ascertain in scenarios we will call *mixed*, namely those where every man owns and beats one donkey, and at least some men own additional donkeys that they do not beat (e.g., Parsons 1978, Heim 1982, Rooth 1987).

We will say that a donkey sentence has a *heterogeneous* interpretation if it is readily judged true in relevant mixed scenarios; otherwise, we will speak of *homogeneous* interpretations. An example whose most salient interpretation is homogeneous is (5a), adapted from Rooth 1987. It is homogeneous because it is judged false as soon as some father lets any of his 10-year-old sons drive the car, even if he has other 10-year-old sons that he forbids from driving it. Two heterogeneous examples are (5b), adapted from Schubert & Pelletier 1989, and (5c), from Chierchia 1995.

- (5) a. No man who has a 10-year-old son lets him drive the car.  
 b. Usually, if a man has a quarter in his pocket, he will put it in the meter.  
 c. No man who has an umbrella leaves it home on a day like this.

As for (4) itself, Chierchia (1995) reports that although it is most readily interpreted in terms of a (homogeneous)  $\forall$ -reading, it turns out to allow quite clearly for (heterogeneous)  $\exists$ -readings in suitable contexts. Chierchia gives this context as a tongue-in-cheek example and attributes it to Paolo Casalegno (see also Almotahari 2011 for a different context manipulation):

- (6) The farmers of Ithaca, N.Y., are stressed out. They fight constantly with each other. Eventually, they decide to go to the local psychotherapist. Her recommendation is that every farmer who has a donkey should beat it, and channel his/her aggressiveness in a way which, while still morally questionable, is arguably less dangerous from a social point of view. The farmers of Ithaca follow this recommendation and things indeed improve.

The distinction between homogeneous and heterogeneous readings cuts across the one between  $\exists$ -readings, such as (5a) and (5b), and  $\forall$ -readings, such as (5c). It also cuts across the distinction between determiner-based donkey sentences, such as (5a) and (5c), and adverbial ones, such as (5b), and across the one between downward

monotone embedding determiners, as in (5a) and (5c), and upward monotone ones, as in (5b). Hence it is not possible to reduce one of these distinctions to another.

The influence of context on donkey sentences has been noticed before:

(7) Anyone who catches a Medfly should bring it to me.

Gawron, Nerbonne & Peters (1991) observe that the interpretation of (7) is different depending on whether the speaker is a biologist looking for samples on a field trip, in which case the  $\exists$ -reading emerges, or a health department official engaged in eradicating the Medfly, in which case the  $\forall$ -reading surfaces.

The account of these facts that we will develop is based on the following intuition: sentence (4) can be paraphrased in a context-independent way as *Things are equivalent for current purposes to the way they would be if every donkey-owner beat all of his donkeys*, modulo the contrary-to-fact implication that this paraphrase suggests. Just what it means to be equivalent for current purposes can be stated in a context-independent way only for two limiting cases: On the one hand, equivalence is reflexive, so that if every donkey-owner actually beats all of his donkeys, (4) is definitely true. On the other hand, we assume that if some donkey-owner does not beat any of his donkeys, (4) is definitely false, just as (2b) is definitely false when no door is open.

Between the scenarios in which a donkey sentence is definitely true and those where it is definitely false lies a no man's land of mixed scenarios. When hearers are pressed to assign a definite truth value to a donkey sentence in such a mixed scenario, they are in effect asked to draw a clear border where the semantics does not provide one. To do this, hearers may resort to various pragmatic strategies. In particular, when the context makes it clear that the scenario can be treated as equivalent for current purposes to scenarios in which the donkey sentence has a definite truth value, they will take that into account. Essentially, this will be the case whenever it is clear how farmers who beat some but not all of their donkeys should be classified for the purposes of the conversation. Whenever the context fails to make this clear, hearers will either hesitate to give any judgments, or they will err on the side of not assuming more equivalence than they have to.

To formalize this theory, we need to make these notions more precise. We turn to the theory in Križ 2016, which provides the scaffolding on which the pragmatic part of our account rests.

### 3 Križ 2016 on plural definites

Sentences with plural definites can receive different interpretations in different contexts in a similar way to donkey sentences. In certain contexts, a predicate can be judged to hold of a plurality denoted by a plural definite even if the predicate is

not strictly speaking true of the whole plurality. This phenomenon has been referred to as *non-maximality* (Brisson 1998, 2003, Lasersohn 1999, Malamud 2012). For example, as mentioned before, if one can reach a safe by going through any one of three doors arranged side by side, and if two of these doors are open, the sentence *The doors are open* is readily judged true. But this is no longer the case if the doors are arranged in a sequence and one needs to pass through all of them. Put in the terms of our view on donkey sentences, *The doors are open* communicates, roughly, that things are equivalent for current purposes to the way they would be if all the doors were open. Thus, *The doors are open* is judged definitely true if all the doors are open, and definitely false if all of them are closed, no matter how they are arranged. If some but not all of them are open, judgments will depend on whether *enough* of the doors are open for the purposes of the conversation, and hearers will have to decide whether the state of affairs is more like one in which all the doors are open or more like one in which none of them are.

Among the various accounts that formalize this process, we adopt the system in Križ 2016 because it is recent and lean; for similar and more elaborate accounts, see van Rooij 2003 and Malamud 2012. To characterize how these different interpretations arise, Križ 2016 assumes a salient Question under Discussion (QUD), a partition of the set of worlds which gives rise to an equivalence relation  $\approx$ . Intuitively,  $w \approx w'$  means that the QUD is resolved in the same way in  $w$  and  $w'$ , and any differences between these two worlds are irrelevant for current purposes. A sentence  $S$  is judged true in a given context just in case it is *true enough at  $w$  with respect to the QUD*, where being “true enough” means being true either at  $w$  itself or at some  $w' \approx w$  (see Lewis 1979, Lasersohn 1999, Malamud 2012).<sup>3</sup>

Križ assumes that sentences can have truth-value gaps (van Fraassen 1969, Schwarzschild 1993). In a scenario when some but not all doors are open, *The doors are open* is literally (at the semantic level) neither true nor false. These literal truth values are not intended to directly reflect native speakers’ intuitions. They are merely an intermediate step on the way towards computing pragmatic truth values. Križ motivates truth-value gaps via the phenomenon known as *homogeneity* or *polarity* (Löbner 1987, 2000). These terms refer to the fact that sentences with definite plurals and negations of such sentences are “neither true nor false when the plurality in question is mixed with respect to the property ascribed to it (modulo the exceptions

<sup>3</sup> We depart from Križ in adopting the term *QUD* instead of his preferred term *Current Issue*. We do this because *QUD* is the term most commonly used to refer to the salient subject matter that speakers and hearers interpret sentences as being about. Križ (2016: 514) is motivated to seek an alternative notion of subject matter because he finds cases in which the pragmatic interpretation of definite plurals seems to be insensitive to explicitly asked questions, which plausibly establish the immediate conversational QUD. We prefer to stick with the common notion, and remain neutral about how to resolve mismatches between the questions that are asked and the questions that answers actually address.

allowed by non-maximality)” (Križ 2016: 494). Consider for example the following sentences:

- (8)     a.    The books were written in Dutch.  
          b.    The books were not written in Dutch.

The literal truth value of (8a) is true if and only if all the books are written in Dutch and false if and only if none of them are, while for (8b) it is the other way round; in all other cases, both sentences are neither true nor false.

To account for the fact that speakers use homogeneous sentences in mixed scenarios, Križ proposes to relax the Gricean Maxim of Quality in the following way. A sentence  $S$  may be used at  $w$  to address the QUD even if it lacks a truth value at  $w$ , as long as it is true enough at  $w$  and not false at any  $w' \approx w$ . This means that speakers may utter a sentence even if they do not believe it to be true, as long as they do not believe it to be false at any world that is equivalent to the actual world. Sentences that are true enough are predicted to be judged true.

Suppose for example that the QUD is whether there is a way to the safe. That is, suppose that  $w' \approx w$  just in case the safe is reachable either in both  $w$  and  $w'$  or in neither  $w$  nor  $w'$ . Say the doors are arranged side by side. Consider two worlds  $w_{all}$ , where all the doors are open, and  $w_{some}$ , where two of three doors are open (a mixed scenario). These worlds are equivalent for current purposes, and *The doors are open* counts as true enough at both of them. Accordingly, it will be interpreted non-maximally (and hence, heterogeneously) as the proposition  $\{w_{all}, w_{some}\}$ . Now consider a context where the doors are arranged in sequence:  $w_{all}$  and  $w_{some}$  are no longer equivalent. Instead,  $w_{some}$  is equivalent to a world  $w_{none}$  where no door is open. Since  $w_{all}$  is the only world at which *The doors are open* is true enough, it is interpreted maximally (and hence homogeneously) as  $\{w_{all}\}$ .

#### 4 Applying Križ 2016 to donkey sentences

As we have seen, for Križ 2016, a truth-value gap divides the worlds in which a sentence with a definite plural is true from those in which it is false. At the worlds in this gap, the plurality in question is mixed with respect to the property ascribed to it. We have claimed that donkey sentences likewise lack a clear border between true and false scenarios. Let us now make this claim more precise by assuming that donkey sentences have truth-value gaps at worlds that correspond to mixed scenarios. Then we can apply the theory in Križ 2016 straightforwardly. Suppose the semantics assigns sentence (4), repeated here, the following truth and falsity conditions:



- (9) Every man who owns a donkey beats it. = (4)
- a. **true** iff every donkey-owner beats every donkey he owns;
  - b. **false** iff at least one donkey-owner does not beat any donkey he owns;
  - c. **neither** otherwise; in particular, if every donkey-owner beats exactly one donkey and someone owns a donkey he does not beat.

We will present a theory that delivers exactly these truth and falsity conditions in Section 5. For the purpose of exposition, though, pretend that there are only three possible worlds. Let  $w_{true}$  be a world where (9a) holds,  $w_{false}$  one where (9b) holds, and  $w_{mixed}$  one where (9c) holds. Assume that the QUD in scenario (6) is whether every farmer follows the recommendation to beat at least one donkey. Then  $w_{true} \approx w_{mixed}$ . Hence (4) is interpreted as  $\{w_{true}, w_{mixed}\}$ ; this is a heterogeneous  $\exists$ -reading.<sup>4</sup> If we change the scenario so that the recommendation is to beat all of one's donkeys,  $w_{mixed}$  and  $w_{false}$  are now equivalent to each other, but not to  $w_{true}$ . This time, (4) is not true enough at  $w_{mixed}$ . It is therefore pragmatically interpreted as  $\{w_{true}\}$ . Since this proposition does not contain  $w_{mixed}$ , sentence (4) receives a homogeneous reading; and since at  $w_{true}$ , every donkey-owner beats all of his donkeys, this is a  $\forall$ -reading. Thus, this theory predicts that the pragmatic interpretation of (4) can be paraphrased roughly as *Things are equivalent to the way they would be if every man who owns a donkey beat all of his donkeys*, except that this paraphrase suggests that not every donkey owner actually beats all of his donkeys. For this paraphrase to make sense, the contribution of *equivalent* needs to be captured. This is precisely the role of the equivalence relation  $\approx$  induced by the QUD.

Turning to donkey sentences headed by *no*, let us first consider one that has the  $\forall$ -reading. Assume that sentence (5c), repeated here, has the following truth and falsity conditions:

- (10) No man who has an umbrella leaves it home on a day like this. = (5c)
- a. **true** iff no umbrella-owner leaves any of his umbrellas home;
  - b. **false** iff at least one leaves all his umbrellas home;
  - c. **neither** otherwise; in particular, if everyone takes exactly one umbrella along, and someone also leaves one home.

As before, let  $w_{true}$ ,  $w_{false}$  and  $w_{mixed}$  be worlds in which (10a), (10b), and (10c) are the case respectively. Suppose that the QUD is whether there is a man with an umbrella who is getting wet. A man gets wet if he fails to take any umbrella along.

<sup>4</sup> This is shorthand. The account presented in Section 5 does not treat a sentence like (4) as denoting  $\{w_{true}, w_{mixed}\}$  directly. Instead, at mixed worlds, (4) is mapped to the truth value **neither**. The pragmatics then treats this sentence as true just in case  $w_{true} \approx w_{mixed}$ .



This is the case at  $w_{false}$ . It is neither the case at  $w_{true}$  nor at  $w_{mixed}$ , so these two worlds are equivalent. Given this QUD, (5c) is therefore true enough at both  $w_{true}$  and  $w_{mixed}$ . Since  $w_{true}$  is not equivalent to  $w_{false}$ , (5c) can be used to address the QUD at both  $w_{true}$  and  $w_{mixed}$ . This means (5c) will be pragmatically interpreted as  $\{w_{true}, w_{mixed}\}$ . Since this proposition contains  $w_{mixed}$ , this is a heterogeneous reading. The strongest thing we can say about both  $w_{true}$  and  $w_{mixed}$  is that no umbrella-owner left *all* (as opposed to *any*) of his umbrellas home. Hence this is a  $\forall$ -reading.

Now let us consider a donkey sentence headed by *no* that has the  $\exists$ -reading. Assume that sentence (5a), repeated here, has the following truth and falsity conditions:

- (11) No man who has a 10-year-old son lets him drive the car. = (5a)
- a. **true** iff no man lets any son of his drive his car;
  - b. **false** iff at least one man has a son and lets all his sons drive his car;
  - c. **neither** otherwise; for example, if every father allows one son to drive the car, and some of them have additional sons that they don't.

Let  $w_{true}$ ,  $w_{false}$  and  $w_{mixed}$  match these propositions as before. Suppose that the QUD is whether there are reckless fathers. Clearly, a father who allows just one of his sons to drive the car is already reckless, as is a father who gives this permission to all of his sons. Reckless fathers are absent from  $w_{true}$  but present at both  $w_{false}$  and  $w_{mixed}$ , so  $w_{false} \approx w_{mixed}$ . Hence (11) is true enough only at  $w_{true}$ . Since  $w_{true} \not\approx w_{false}$ , (11) can be used to address the QUD. This means (5a) will be pragmatically interpreted as  $\{w_{true}\}$ . Therefore, (11) receives a homogeneous reading. Since at  $w_{true}$ , no father lets any of his sons drive the car, this is the  $\exists$ -reading.<sup>5</sup>

We have focused on the  $\exists$ -reading and the  $\forall$ -reading so far. Arguably, these readings are endpoints on a continuum whose interior is notoriously difficult to probe. Thus Rooth (1987: 256) remarks:

Consider *Most farmers who own a donkey beat it*: does it mean that most farmers who own a donkey beat all of the donkeys they own, that most farmers who own a donkey beat most of the donkeys they own, or that most farmers who own a donkey beat some of the donkeys they own? I am simply not sure, and informants I have consulted have not expressed strong or consistent opinions.

<sup>5</sup> Some donkey sentences are formulated in such a way as to make mixed scenarios logically or practically impossible, such as *Most farmers who own exactly one donkey beat it* or *Most men who have a Social Security number know it by heart* (see Kanazawa 1994: 113). For the latter sentence, the “mixed” scenarios would involve people who have more than one Social Security number (something impossible in the current U.S. context).

The theory we present here treats the  $\exists/\forall$  dichotomy as a case of underspecification rather than ambiguity, and generates  $\exists$ -readings,  $\forall$ -readings, as well as intermediate interpretations. Given natural assumptions about the QUDs that sentences address, our theory makes predictions about the availability of such intermediate interpretations. Consider for example the following pair of sentences:

- (12) a. Every student who took a course from Peter last year liked it.  
 b. Most students who took a course from Peter last year liked it.

As Kanazawa (1994: 116) reports, native speaker judgments suggest that

while [(12a)] clearly requires every student to like every course he or she took from Peter, [(12b)] can be judged true even in situations where half of the students who took a course from Peter didn't like some of the courses they took from him. . . . Responses from my informants did not indicate that [(12b)] has the weak reading, however. The exact truth conditions of [(12b)] seem unclear.

These judgments are expected under the assumption that (12a) is naturally understood as addressing the QUD *Were Peter's courses universally well-liked?* while (12b) is understood as addressing the QUD *Were Peter's courses generally well-liked?* Given this assumption, our account predicts that (12b) is interpreted as *Things are equivalent for current purposes to the way they would be if most students in Peter's courses liked all of the courses they took from Peter*. On our account, the less-than-universal threshold that is inherent in the generic quantifier *generally* is transmitted to sentence (12b) via the QUD; although we do not attempt to formally capture this, it is natural to expect that uncertainty about that threshold results in uncertainty about what this QUD is, specifically uncertainty about what proportion of classes one needs to like in order to count as a relevant class-liker.

One benefit of the theory developed here is that it accounts for the observation that “people have firm intuitions about situations where farmers are consistent about their donkey-beating” while they give “varied and guarded judgments” in mixed scenarios (Rooth (1987); see also Parsons 1978 and Jackson 1994: 136). This behavior is expected on the natural assumption that hearers will hesitate just in case (i) they cannot easily identify the QUD, and (ii) they are given a donkey sentence and a scenario that leads to a truth-value gap. Consistent situations will not give rise to truth-value gaps.

It has been proposed that donkey pronouns carry uniqueness conditions of various sorts (Parsons 1978, Cooper 1979, Kadmon 1990); however, this proposal is controversial (e.g., Brasoveanu 2008: Section 5). We do not ascribe any uniqueness conditions to pronouns. Situations that meet uniqueness conditions, for example

situations in which every farmer owns at most one donkey, do not have any privileged status on our account; they are simply one kind of consistent situation. Our account treats them analogously to other kinds of consistent situations such as the following:

- (13) *Scenario:* Sage plants are sold in batches of nine.  
Everybody who bought a sage plant here bought eight others along with it.

This example was brought up by Heim 1982 to argue against certain types of uniqueness conditions on pronouns. Kadmon 1990 argues that hearers who accept it do so in spite of uniqueness conditions because it cannot make any difference to truth conditions which sage plant the pronoun stands for.<sup>6</sup> Our semantics on the other hand delivers a classical truth value (true) in the scenario described. We consequently predict that hearers should not hesitate to give clear judgments in this situation because the denotation does not depend on how pragmatic factors like the QUD are resolved. This is in line with a speculation by Kanazawa (1994: 152):

[P]eople are capable of assessing the truth value of a donkey sentence without resolving the ‘vagueness’ of the meaning given by the grammar when there is no need to do so. For our purposes, it is enough to assume that underspecification causes no problem for people in assigning a truth value to a donkey sentence in situations where the uniqueness condition for the donkey pronoun is met. These are a special class of consistent donkey-beating situations, and the uniqueness condition can be checked just by looking at the extensions of the predicates in the N’ of the sentence.

The present account extends Kanazawa’s perspective to all consistent situations, such as the sage-plant scenario in (13). Even though the uniqueness condition for the pronoun in (13) is not met, we still predict that sentence (13) will be judged true independently of any assumptions about the QUD, because the scenario does not fall into the sentence’s truth-value gap.<sup>7</sup>

<sup>6</sup> This idea foreshadows our supervaluationist treatment of quantifiers in Section 5. The connection to supervaluation treatments of vagueness was noted by Mats Rooth (p.c.) in Heim 1990: n. 11. Heim argues against Kadmon’s supervaluationist idea by pointing out that judgments on a variant of the car-lending example (11) are more secure than Kadmon predicts them to be. We take it that this is because example (11) makes it easy to accommodate the QUD, namely whether there are reckless fathers.

<sup>7</sup> Even mixed scenarios are sometimes assigned a classical truth value by the semantics here, and are therefore not dependent on the QUD for their interpretation. Thus if every man owns two donkeys, John beats neither of his donkeys, and everyone else beats only one of his donkeys, our semantics predicts sentence (9) to be false no matter what the QUD is. This leads us to expect that hearers should not hesitate to judge such a sentence false. We believe that this is on the whole correct (but

Our account relies on the assumption that hearers interpret a sentence as addressing the QUD. This is a common assumption in theories of information structure (Roberts 2012). There is evidence that both adults and children use this assumption to disambiguate sentences in context, even when no question has been explicitly asked (Gualmini et al. 2008). Following Križ (2016: 514), we take the formal notion of QUD to represent the overarching goals of the discourse participants, as relevant to the conversation. These goals can but need not be determined by an explicit question in the conversation. We assume that hearers can try to infer from sentences and scenarios what the QUD might be; that is, they can *accommodate* QUDs. Accommodation of QUDs becomes particularly relevant when hearers are presented donkey sentences out of context. One natural principle that hearers may use to infer QUDs, inspired by David Lewis’s notion of Aboutness, is proposed by Križ (2016):

(14) **Addressing the QUD**

A sentence  $S$  may not be used to address the QUD if there are  $w_1$  and  $w_2$  such that  $w_1 \approx w_2$  and  $S$  is true at  $w_1$  but false at  $w_2$ .

If hearers assume that speakers follow this principle, they will generally be able to infer many properties of the QUD from the sentence. When hearers cannot easily infer or accommodate the QUD, they cannot assign a pragmatic truth value to sentences that are neither true nor false at the semantic level, and they may become confused; hence the “varied and guarded” judgments observed by Rooth (1987) and others.

The broader question of how interlocutors converge on the QUD given the state of the discourse is currently open in the literature on pragmatics. For relevant discussion of the constraints on question accommodation and pointers to the literature, see Beaver & Clark 2008: Section 2.7; for a Bayesian approach to QUD inference, see Kao et al. 2014. In particular, Beaver & Clark propose that accommodated QUDs must maximize the relevance of the sentence and that they must be *calculable*; that is, they must be jointly identifiable by speaker and hearer as a common means to discourse goals. For example, in the case of the classic donkey sentence in (4), an unusual QUD such as *Does every donkey-owning farmer beat at least one donkey he owns and moreover beat every male donkey he owns?* would not normally be calculable.

A further possibility is that the relationship between QUDs and the sentences that address them is constrained by question-answer congruence, that is, the notion that the answer and its focus alternatives must match the possible answers of the

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see Kanazawa 2001: Section 6.2 for a different perspective, and Brasoveanu 2008: Section 5.2 for further discussion). We return to Kanazawa 1994 in Section 6.1.

question (e.g., Roberts 2012). This might be the reason why (12a) does not lead hearers to accommodate QUDs such as *Did all of Peter's students like more than half of the classes they took with him?* and cannot be used to answer such questions in the affirmative. Likewise, question-answer congruence might well be the reason why (12a) and (12b) are understood as addressing the QUDs *Were Peter's courses universally well-liked?* and *Were Peter's courses generally well-liked?* respectively rather than vice versa. Formalizing question-answer congruence would require, among other things, clarifying what it means for a trivalent proposition to match a possible answer to a question and what the focus alternatives of donkey sentences are; we leave this for future work.<sup>8</sup>

To sum up this section, we have proposed a simple pragmatic theory that expects the semantic component to pass it a trivalent proposition. Given the QUD (formalized as an equivalence relation over possible worlds), the theory maps the trivalent proposition to an ordinary bivalent proposition that is true in mixed scenarios whenever the QUD lumps those scenarios together with worlds at which the proposition is true. The theory developed here treats uniqueness as an epiphenomenon and does not assume that donkey pronouns come with uniqueness constraints. While we refrain from predicting how interlocutors converge on a QUD, we have proposed that QUDs and the sentences that address them are mutually constrained, and that hearers can accommodate QUDs by exploiting these constraints as well as various features of the context.

## 5 A trivalent dynamic compositional semantics

With a pragmatic theory in place that combines trivalent meanings with QUDs to deliver disambiguated readings, our next task consists in delivering these trivalent meanings compositionally. In this section, we do so by building on a simple dynamic semantic framework originally described in Muskens 1995. This fits our overall strategy of showing how the apparent complexity of the  $\exists/\forall$  dichotomy follows from the interaction of two relatively simple independently motivated formal systems.

As mentioned in Section 1, many early theories assumed that singular donkey pronouns can pick up both atoms and sums as discourse referents, so that the donkey pronoun in the classic sentence (9) could be paraphrased as *the donkey or donkeys*

<sup>8</sup> A similar question is discussed in connection with plural definites in Križ 2016: Section 4.5, who considers an exam that one can pass by either solving all the math problems, or by solving half of them and writing an essay. When asked whether Peter passed the exam, the answer *Yes, he solved the math problems* conveys that Peter chose not to write the essay. Križ notes, based on observations by Benjamin Spector (p.c.) and an anonymous reviewer, that this is unexpected if the explicitly asked question is taken to be the QUD; in that case, on his theory the answer should simply entail that Peter solved enough problems to pass the exam, and should leave it open whether he decided to write the essay.

*he owns* (Lappin & Francez 1994, Yoon 1994, 1996, Krifka 1996). But as we have seen, Kanazawa 2001 argues convincingly that singular donkey pronouns can only have atomic discourse referents. With this in mind, several frameworks have been proposed that do not interpret singular donkey pronouns as sum individuals, in particular, dynamic systems such in the tradition of Groenendijk & Stokhof 1991. A precursor of the present work, which we discuss in Section 6.6, relied on Brasoveanu’s (2008) plural compositional discourse representation theory (plural CDRT or PCDRT) to generate and manage discourse referents (Champollion 2016). In this paper, we eschew PCDRT in favor of a simpler CDRT variant that does not make use of plural assignments.<sup>9</sup> In Section 6, we argue that donkey ambiguities do not require the full power of PCDRT.

At the core of dynamic systems for anaphora is the notion of an assignment. Assignments relate discourse referents  $d, e, f$ , etc., to entities  $x, y, z$ , etc. The lean semantics in Muskens 1995 is similar to Ty2 (Gallin 1975) but includes a third basic type,  $s$  (for *state* or *store*), in addition to the usual  $e$ , the type of entities, and  $t$ , the type of truth values.<sup>10</sup> There are two common strategies for conceptualizing the way that objects of type  $s$  track anaphora (Janssen 1983, Muskens 1991). Either  $s$  is taken to be the type of discourse referents, in which case assignments are modeled as functions from discourse referents to their values, or  $s$  is taken to be the type of assignments, in which case discourse referents are modeled as functions from assignments to values (in this case they are conceptually similar to the file cards in Heim 1983). As long as these values all have the same type, such as individuals, the choice between these two options does not matter. Since we are only interested in anaphora to individuals, we use the primitive type  $s$  for discourse referents (of which we assume that there are infinitely many) and we represent assignments as functions of type  $\langle s, e \rangle$ , from discourse referents to their values. The converse choice would also be possible and is in fact adopted in Muskens 1991, 1995, 1996 and in Brasoveanu 2007, 2008. Since those works treat assignments as primitive, they

<sup>9</sup> The most influential variant of CDRT is described in Muskens 1996; for example, Brasoveanu’s (2008) PCDRT is based on it. We build instead on the variant in Muskens 1995. The main difference between is that in Muskens 1996, verbal predicates apply to discourse referents while in Muskens 1995 they apply to entities. The latter option is arguably conceptually simpler and makes it somewhat easier to integrate static generalized quantifiers (which apply to sets of entities) into the system we develop in the following.

<sup>10</sup> In the interest of simplicity and readability, throughout this section we suppress possible worlds, as well as other basic types that Muskens uses but that are not needed here, such as events and periods of time. The only place in our system where trivalence appears is in the outputs of quantificational determiners. To keep things simple, we set aside questions about how this trivalence projects through other operators that may embed donkey sentences; and we assume that the arguments to all the functions in our compositional fragment are always bivalent. For compositional semantic systems that allow trivalent arguments, see Magri 2014 and Križ 2015.



provide sets of axioms to ensure that these *assignment objects* behave in the way *assignment functions* do. Such axioms are unnecessary here.

Sentences denote relations between assignments, or what we will refer to as dynamic propositions. By convention, we will use  $i, i'$ , etc. as variables over the first component of a relation denoted by a main clause, and  $o, o'$ , etc. as variables over the second. These letters are mnemonics for *input assignment* and *output assignment* respectively. When intermediate assignments are needed, we write  $j, j'$ , etc. for them. We let  $d, e, f$ , and primed versions thereof range over discourse referents. To make it easier for the reader to keep track of discourse referents, we use the letters  $d$  and  $f$  for discourse referents associated with the words *donkey* and *farmer*, respectively. Finally,  $\mathbf{t}$  abbreviates  $\langle se, \langle se, t \rangle \rangle$ , the type of dynamic propositions.

Suppose  $i$  and  $o$  are assignments and  $d$  is a discourse referent. We want  $i[d]o$  to mean that  $i$  and  $o$  agree on all things except possibly on the value they assign to  $d$ . This is guaranteed by the following definition:<sup>11</sup>

$$(15) \quad i[d]o \equiv \forall d'_s. d' \neq d \rightarrow i d' = o d'$$

Like many other dynamic theories, CDRT assumes that anaphoric links are encoded in LFs through coindexation. Indefinites are superscripted with the discourse referents they introduce, and anaphoric elements such as pronouns are subscripted with the discourse referents they pick up. For example, here is (9) with the relevant annotations:

$$(16) \quad \text{Every farmer who owns a}^d \text{ donkey beats it}_d$$

The lexical entries in Table 1 are based on [Muskens 1995](#): Section 5 with slight modifications. Determiners are given static entries, with the exception of the indefinite  $a$ . In line with common practice in dynamic frameworks, we treat indefinites separately from other determiners. The restrictor and the nuclear scope of sentence (9) reduce to the following by a series of lambda conversions and equivalent simplifications:

$$(17) \quad \begin{array}{l} \text{a. } \lambda x i o. \text{ farmer } x \wedge i[d]o \wedge \text{ donkey } (o d) \wedge \text{ owns } x(o d) \\ \text{b. } \lambda x i o. \text{ beats } x(i d) \wedge i = o \end{array}$$

<sup>11</sup> We use the following notational conventions. Dots separate binding operators — including  $\lambda$ ,  $\exists$ , and  $\forall$  — from the formulas that they quantify over. The scope of an operator extends as far to the right as possible (until the edge of the nesting group), so for instance, in the formula  $(\exists x. P x \wedge Q x) \wedge R x$ , the variable  $x$  is bound in  $P x \wedge Q x$ , but free in  $R x$ . Prefixal lambdas are collapsed:  $\lambda f x. f x$  abbreviates  $\lambda f. \lambda x. f x$ . Finally, arguments are passed into functions without the aid of parentheses (which are used only for grouping), so that  $f x$  represents  $f$  applied to  $x$ ,  $i d$  represents  $i$  applied to  $d$ , etc.



<i>Phrase</i>	<i>Type</i>	<i>Translation</i>
every	$\langle et, \langle et, t \rangle \rangle$	$\lambda PQ. \forall x. Px \rightarrow Qx$
no	$\langle et, \langle et, t \rangle \rangle$	$\lambda PQ. \neg \exists x. Px \wedge Qx$
(at least) $n$	$\langle et, \langle et, t \rangle \rangle$	$\lambda PQ.  P \cap Q  \geq n$
exactly $n$	$\langle et, \langle et, t \rangle \rangle$	$\lambda PQ.  P \cap Q  = n$
farmer	$\langle e, \mathbf{t} \rangle$	$\lambda xio. i = o \wedge \text{farmer } x$
who	$\langle \mathbf{et}, \langle \mathbf{et}, \mathbf{et} \rangle \rangle$	$\lambda PQxio. \exists j. Qxi j \wedge Px j o$
owns	$\langle \langle \mathbf{et}, \mathbf{t} \rangle, \mathbf{et} \rangle$	$\lambda Gx. G(\lambda yio. i = o \wedge \text{own } xy)$
$a^d$	$\langle \mathbf{et}, \langle \mathbf{et}, \mathbf{t} \rangle \rangle$	$\lambda PQio. \exists j \exists j'. i[d] j \wedge P(jd) j j' \wedge Q(jd) j' o$
donkey	$\langle e, \mathbf{t} \rangle$	$\lambda xio. i = o \wedge \text{donkey } x$
beats	$\langle \langle \mathbf{et}, \mathbf{t} \rangle, \mathbf{et} \rangle$	$\lambda Gx. G(\lambda yio. i = o \wedge \text{beat } xy)$
$it_d$	$\langle \mathbf{et}, \mathbf{t} \rangle$	$\lambda Pio. i = o \wedge P(id) io$

**Table 1** Basic translations

In the restrictor, (17a), the indefinite *a donkey* introduces the discourse referent  $d$  and makes sure it picks out a donkey. The variable  $x$  ranges over individuals; its value must be a farmer who owns the donkey in question. In a dynamic setting, it is the job of the embedding determiner to pass on the assignments obtained in this way to the nuclear scope, (17b), which examines each assignment as to whether the farmer beats the donkey picked out by  $d$ .

This sketch leaves open what happens when the restrictor encounters a farmer who owns two or more donkeys. In such a case, it will relate one and the same input assignment to several output assignments, a different one for each donkey the farmer owns. The question arises whether the embedding determiner should require that its nuclear scope apply to only one of these output assignments, or to all of them. Static determiners can be lifted into the dynamic setting in two ways, each corresponding to one of these options (Chierchia 1995).

We propose that both options are operative in the semantics of donkey sentences. An embedding determiner like *every*, *no*, or *exactly two* checks whether they both lead to the same outcome. If they do, the sentence as a whole is assigned that outcome as a classical truth value; otherwise, it receives the truth value **neither**.

Our proposal is independently motivated by the findings in Experiment A3 of Križ & Chemla 2015, which asked participants to evaluate the truth of sentences like (18) with respect to pictures that involved four cells, all filled with circles of different colors.

(18) In exactly 2 of the 4 cells, the circles are blue.

The plural definite in the subject of *the circles are blue* is the source of trivalence in this example. It is true in cells that contain only blue circles (“all-blue cells”), false in cells that contain no blue circles (“no-blue cells”) and neither true nor false in cells that contain both blue and non-blue circles (“mixed cells”). Križ & Chemla ran their experiment to determine the way in which this trivalent behavior projects to sentence (18) as a whole. To this purpose, they varied the number of cells on display of each type, holding the sentence constant, and they gave participants the answer options *completely true*, *completely false*, and *neither*. On the whole, participants who saw two all-blue and two non-blue cells judged (18) completely true; those who were shown fewer than two cells with any blue circles in them judged it completely false, as did those who saw more than two all-blue cells; and participants judged (18) neither true nor false when exactly two cells had any blue circles, but at most one of these cells was all-blue. As Križ & Chemla note, this pattern can be described succinctly by using the following two sentences (which were not shown to the participants). In any scenario where these two sentences have the same truth value (either both true or both false), participants judged (18) to have that truth value, and otherwise participants judged (18) neither true nor false.

- (19) a. In exactly 2 of the 4 cells, all the circles are blue.  
 b. In exactly 2 of the 4 cells, at least some of the circles are blue.

In the following, we generalize this pattern by abstracting away from the specific embedding quantifier and from the specific source of trivalence. We first define two type shifters  $\mathfrak{E}$  and  $\mathfrak{A}$ , which lift a static determiner  $D$  of type  $\langle et, \langle et, t \rangle \rangle$  into its internally dynamic counterparts. These type shifters correspond to the schemata  $\mathcal{Q}_w$  and  $\mathcal{Q}_s$  in Kanazawa 1994: 138, where they are attributed to Chierchia; similar schemata are sketched in Heim 1990 and attributed to unspecified previous literature. Here we write  $R$  and  $N$  for the restrictor and nuclear scope of these dynamic determiners; these variables are both of type  $\langle e, t \rangle$  because they each take an individual and return a dynamic proposition.

- (20) a.  $\mathfrak{E} \stackrel{\text{def}}{=} \lambda DRNi. D(\lambda x. \exists j. Rxi j) (\lambda x. \exists j. Rxi j \wedge \exists o. Nx j o)$   
 b.  $\mathfrak{A} \stackrel{\text{def}}{=} \lambda DRNi. D(\lambda x. \exists j. Rxi j) (\lambda x. \forall j. Rxi j \rightarrow \exists o. Nx j o)$

On the basis of these type shifters, we define a new type shifter that takes a static determiner  $D$  and returns an internally dynamic determiner that behaves as desired:

$$(21) \quad \mathfrak{D} \stackrel{\text{def}}{=} \lambda DRNi o. \begin{cases} \mathbf{true} & \text{if } i = o \wedge \mathfrak{E}DRNi \wedge \mathfrak{A}DRNi \\ \mathbf{false} & \text{if } i = o \wedge \neg \mathfrak{E}DRNi \wedge \neg \mathfrak{A}DRNi \\ \mathbf{neither} & \text{otherwise} \end{cases}$$

In particular, this determiner returns **true** when  $\mathfrak{E}$  and  $\mathfrak{A}$  are both true; it returns **false** when they are both false; and it returns **neither** when they disagree. In order to maintain compatibility with the rest of the grammar, we also equip the lifted determiner with two lambda slots for input and output assignments. To keep things simple, and because this paper does not deal with discourses, we require these assignments to be identical, making the lifted determiner externally static. For the same reason, we omit the treatment of discourse referents introduced by quantifiers themselves.

In many cases, the truth conditions that result from the  $\mathfrak{D}$  type shifter can be presented in a simplified way. For example, in the case of *every*, the  $\mathfrak{A}$  proposition asymmetrically entails the  $\mathfrak{E}$  proposition; for *no*, it is the other way around. Taking this into account, the output of  $\mathfrak{D}$  for these two determiners can be represented as follows:

$$(22) \quad \mathfrak{D}_{every} \stackrel{\text{def}}{=} \mathfrak{D} \llbracket \text{every} \rrbracket =$$

$$\lambda RNio. \left\{ \begin{array}{ll} \mathbf{true} & \text{if } i = o \wedge \\ & \forall x. (\exists j. Rxi j) \rightarrow \forall j. Rxi j \rightarrow \exists o'. Nx j o' \\ \mathbf{false} & \text{if } i = o \wedge \\ & \exists x. (\exists j. Rxi j) \wedge \neg \exists j. Rxi j \wedge \exists o'. Nx j o' \\ \mathbf{neither} & \text{otherwise} \end{array} \right.$$

$$(23) \quad \mathcal{D}_{no} \stackrel{\text{def}}{=} \mathcal{D} \llbracket \text{no} \rrbracket =$$

$$\lambda RNio. \begin{cases} \mathbf{true} & \text{if } i = o \wedge \\ & \forall x. (\exists j. Rxi j) \rightarrow \forall j. Rxi j \rightarrow \neg \exists o'. Nxj o' \\ \mathbf{false} & \text{if } i = o \wedge \\ & \exists x. (\exists j. Rxi j) \wedge \forall j. Rxi j \rightarrow \exists o'. Nxj o' \\ \mathbf{neither} & \text{otherwise} \end{cases}$$

In the case of nonmonotonic determiners like *exactly n* or *an even number of*, the  $\mathcal{A}$  and  $\mathcal{E}$  propositions do not stand in an entailment relation. As a result, these determiners look somewhat more complex when they have been lifted. For example, here is  $\mathcal{D}_{\text{exactly } n}$ :

$$(24) \quad \mathcal{D}_{\text{exactly } n} \stackrel{\text{def}}{=} \mathcal{D} \llbracket \text{exactly } n \rrbracket =$$

$$\lambda RNio. \begin{cases} \mathbf{true} & \text{if } i = o \wedge \\ & \left( \begin{array}{l} n = |\{x \mid \exists j. Rxi j \wedge \exists o'. Nxj o'\}| \wedge \\ n = |\{x \mid (\exists j. Rxi j) \wedge \forall j. Rxi j \rightarrow \exists o'. Nxj o'\}| \end{array} \right) \\ \mathbf{false} & \text{if } i = o \wedge \\ & \left( \begin{array}{l} n > |\{x \mid \exists j. (Rxi j \wedge \exists o'. Nxj o')\}| \vee \\ n < |\{x \mid (\exists j. Rxi j) \wedge \forall j. Rxi j \rightarrow \exists o'. Nxj o'\}| \end{array} \right) \\ \mathbf{neither} & \text{otherwise} \end{cases}$$

To understand the behavior of nonmonotonic quantifiers, it is helpful to keep in mind that the output of  $\mathcal{D}$  produces a definite truth value whenever it does not matter how doubtful cases are resolved. For example, *An even number of farmers who have a donkey beat it* is interpreted as definitely true just in case the number of farmers who beat all their donkeys, and the number of farmers who beat at least one donkey, are both even; and definitely false just in case these numbers are both odd. This reflects the finding by [Križ & Chemla 2015](#) that a sentence embedded by a cardinality quantifier has a definite truth value just in case that truth value does not depend on how entities that fall into a truth-value gap are counted.

Since our semantics interprets sentences as dynamic propositions (relations between assignments) but our pragmatics expects trivalent truth values, we assume that dynamic propositions are mapped to trivalent truth values by the following two bridging principles. First, we define truth and falsity relative to an assignment as follows:

(25) **Bridging Principle 1**

Let  $i$  be an assignment and  $\phi$  be a term of type  $\mathbf{t}$ .

- a.  $\phi$  is true relative to  $i$  iff there is an assignment  $o$  such that  $\phi i o$  is true.
- b.  $\phi$  is false relative to  $i$  iff it is not true relative to  $i$  and there is an  $o$  such that  $\phi i o$  is false.
- c. In all other cases,  $\phi$  is neither true nor false relative to  $i$ .

There is an asymmetry in the definition of truth relative to an assignment. Falsity requires non-truth relative to  $i$ , while truth does not require non-falsity. This is so that externally dynamic sentences like *A man arrived* come out true but not false in models that contain a man who arrived and some other entity, such as another man, who did not arrive.

For sentences without unresolved anaphoric dependencies, we define truth and falsity simpliciter by universally quantifying over input assignments:

 (26) **Bridging Principle 2**

Let  $\phi$  be a term of type  $\mathbf{t}$ .

- a.  $\phi$  is true iff it is true relative to every input assignment.
- b.  $\phi$  is false iff it is false relative to every input assignment.
- c. In all other cases,  $\phi$  is neither true nor false.

We restrict Bridging Principle 2 to sentences that do not have unresolved anaphoric dependencies in order to avoid collapsing the truth conditions of pronouns and corresponding universals. Without this constraint, a sentence like *He sat down* would have the same truth conditions as *Every man sat down* under this second principle.

These entries and principles deliver the desired truth and falsity conditions for our examples. As we have seen, the restrictor phrase *farmer who owns a<sup>d</sup> donkey* reduces to (17a), and the nuclear scope phrase *beats it<sub>d</sub>* reduces to (17b). After plugging these terms into the shifted determiner  $\mathcal{D}_{\text{every}}$  in (22) and applying the two bridging principles, we obtain the following truth and falsity conditions for the classic donkey sentence in (9):

$$(27) \left\{ \begin{array}{l} \mathbf{true} \quad \text{if } \forall i \forall x. (\exists j. \text{frm } x \wedge i[d]j \wedge \text{dnk}(jd) \wedge \text{own } x(jd)) \\ \quad \quad \quad \rightarrow \forall j. \left( \begin{array}{l} \text{frm } x \wedge i[d]j \wedge \\ \text{dnk}(jd) \wedge \text{own } x(jd) \end{array} \right) \rightarrow \text{beat } x(jd) \\ \mathbf{false} \quad \text{if } \forall i \exists x. (\exists j. \text{frm } x \wedge i[d]j \wedge \text{dnk}(jd) \wedge \text{own } x(jd)) \\ \quad \quad \quad \wedge \forall j. \left( \begin{array}{l} \text{frm } x \wedge i[d]j \wedge \\ \text{dnk}(jd) \wedge \text{own } x(jd) \end{array} \right) \rightarrow \neg \text{beat } x(jd) \\ \mathbf{neither} \quad \text{otherwise} \end{array} \right.$$

These are precisely the truth and falsity conditions listed in (9), as desired. That is, the sentence is true only if every donkey-owning farmer beats all of their donkeys, and false only if some donkey-owning farmer beats none of their donkeys. Analogously, for the car-lending sentence (11), we obtain the following result from the entry in (23) and the bridging principles:

$$(28) \quad \left\{ \begin{array}{l} \mathbf{true} \quad \text{if } \forall i \forall x. (\exists j. \text{man } x \wedge i[d]j \wedge \text{son } x(jd)) \\ \quad \quad \quad \rightarrow \forall j. \left( \begin{array}{l} \text{man } x \wedge i[d]j \wedge \\ \text{son } x(jd) \end{array} \right) \rightarrow \neg \text{lets-drive } x(jd) \\ \mathbf{false} \quad \text{if } \forall i \exists x. (\exists j. \text{man } x \wedge i[d]j \wedge \text{son } x(jd)) \\ \quad \quad \quad \wedge \forall j. \left( \begin{array}{l} \text{man } x \wedge i[d]j \wedge \\ \text{son } x(jd) \end{array} \right) \rightarrow \text{lets-drive } x(jd) \\ \mathbf{neither} \quad \text{otherwise} \end{array} \right.$$

Once again, these are precisely the desired truth and falsity conditions listed in (11). The **true** case states that there is no way of assigning a man to any son of his such that the man in question lends the son in question his car. The **false** case states that there is a man who has at least one son and who lends every one of his sons the car.

Our fragment attributes trivalence in donkey sentences to their embedding quantifiers. This raises the question of whether the indefinite determiners that antecede donkey pronouns should, by analogy, be taken to introduce trivalence as well. We expect that the answer to this is no. In our fragment, trivalence is introduced by the  $\mathfrak{D}$  type shifter, which is a mechanism for reinterpreting static relations between properties (generalized quantifiers) in such a way that they accommodate dynamicity in their restrictors and nuclear scopes. But in all dynamic frameworks, indefinites are *inherently* dynamic; at their core, they denote operations that introduce discourse referents. In our framework there is never any need to apply  $\mathfrak{D}$  to indefinite determiners, since they are already dynamic, and thus there is never any resulting trivalence. In fact, since  $\mathfrak{D}$  is only defined on static generalized quantifiers, we predict not only that there is no *need* to apply  $\mathfrak{D}$  to indefinites, but that there is no *opportunity* to do so in any case. For example, the only reading that our fragment predicts for sentence (29a) is described by the formula in (29b).

- (29) a. A farmer who owns a donkey beats it.  
 b.  $\lambda i o. \exists j. i[f]j \wedge \text{farmer}(jf) \wedge j[d]o \wedge \text{donkey}(od) \wedge \text{own}(of)(od) \wedge \text{beat}(of)(od)$

This corresponds to an  $\exists$ -reading of the sentence. It is true just in case some farmer owns and beats some donkey, and false otherwise. The  $\forall$ -reading would additionally

require that farmer to beat every donkey he owns. We predict this reading to be absent. While this appears to be correct, we will see in Section 6.3 that any putative  $\forall$ -readings of donkey sentences with upward monotone embedding determiners such as *a* would be very hard to detect anyway (Geurts 2002). In any case, our point here is that no problem arises from the fact that  $\mathfrak{D}$  cannot apply to embedding instances of *a*.

Assigning *a* an inherently dynamic type and thereby putting it into a separate semantic class from other determiners is common in dynamic frameworks, and is usually motivated at least in part by the differential scope and binding behavior of indefinites and genuinely quantificational DPs. Admittedly, it is not always easy to draw the line between these two classes; for relevant discussion, see for example Kamp & Reyle 1993: Chapter 4 and Szabolcsi 1997. That said, for concreteness we suggest treating the word *some* the same way as *a*. As for other indefinite determiners, such as bare numerals, we assume that they have at least the static type  $\langle et, \langle et, t \rangle \rangle$ , as seen in Table 1. Our fragment can be extended to treat plural pronominal anaphora, for example by giving bare numerals additional entries of the dynamic type  $\langle et, \langle et, \mathbf{t} \rangle \rangle$  that parallel that of the indefinite article *a* by introducing reference to sums, but to keep things simple, we set numeral indefinites aside. For more discussion on plural pronominal anaphora in a dynamic context, see Kanazawa 2001 and Nouwen 2003. As for true quantifiers like *every* and *no*, and modified numerals like *at most n*, we assume that they only have the static type, which requires  $\mathfrak{D}$  for any sort of dynamicity. When such modified numerals do introduce (external) discourse referents, we assume that this is due to an abstraction operation that is compatible with static types (Kamp & Reyle 1993, Nouwen 2003). Again to keep things simple, and because we do not model intersentential anaphora, we do not introduce abstraction here.

To summarize, this section has shown how a simple variant of CDRT can be used to deliver trivalent meanings to a pragmatic component, independently motivated by Križ 2016, that can disambiguate those sentences that are neither true nor false relative to the QUD.<sup>12</sup> The following section compares our approach to previous accounts of the interpretation of donkey sentences. In each case, we argue that the account presented here is preferable, either in terms of its formal simplicity or conceptually in how it assigns work to the semantics and pragmatics.

12 While we treat Križ’s (2016) pragmatics as a separate component by which trivalent meanings are (potentially) disambiguated, there are other interesting options that collapse these separate components into a single semantic system. For instance, a reviewer suggests we could treat the notion “true enough” as a modal operator with an accessibility relation given by  $\approx$ , which could interact compositionally in donkey sentences as we have interpreted them here. This would be an interesting formal system to explore in future work; we believe, though, that the result would only differ architecturally from the account presented here.



## 6 Comparison with previous work

There are factors other than the QUD that are involved in the interpretation of donkey sentences. Different donkey sentences seem to differ in the clarity of people’s intuitions about them in neutral contexts and in the degree to which they are susceptible to manipulation by context. The exact nature of such differences is far from established fact. The question of which factors affect the  $\exists/\forall$  dichotomy has been taken on by many authors (Heim 1990, Gawron, Nerbonne & Peters 1991, Chierchia 1992, 1995, Geurts 2002, Foppolo 2012). We first focus on three proposals which are similar in spirit to ours in that they do not postulate a semantic ambiguity: Kanazawa 1994, Barker 1996, and Geurts 2002. The related question of how to formally represent the ambiguity has been addressed thoroughly as well (e.g., Groenendijk & Stokhof 1991, Dekker 1993). In this respect, our theory is similar to many accounts couched in ordinary dynamic predicate logic or compositional versions thereof, such as compositional DRT (Muskens 1995, 1996). We focus our comparison on more recent accounts that use Plural Compositional DRT to represent the ambiguity (Brasoveanu 2008, 2010, Champollion 2016).

### 6.1 Kanazawa 1994

Kanazawa 1994 investigates the properties of donkey sentences with determiners and relative clauses, and focuses on the monotonicity properties of the static version of the embedding determiner. He aims to describe and explain generalizations about how existential and universal readings correlate with these monotonicity properties. He models the  $\exists/\forall$  dichotomy by defining two dynamic generalized quantifiers for each determiner, derived via the type shifters we have referred to as  $\mathfrak{A}$  and  $\mathfrak{E}$ , and by postulating interpretive principles that motivate these type shifters and constrain the choice between them. While subsequent authors have sometimes understood this as a claim that determiners are ambiguous, King & Lewis (2016: n. 31) point out that Kanazawa takes himself to be simply “modeling” the readings of donkey sentences and not actually proposing a semantics.

The main topic of the present work is the role of context in selecting an interpretation of a given donkey sentence. While Kanazawa acknowledges that context plays a role, he addresses the way this happens only briefly in the last paragraph of his paper. His tentative suggestion is that when the speaker’s meaning is clear from the beginning, the hearer does not have to figure out what is meant, and consequently will not go into the trouble of invoking inference. For a critique of this view, see Geurts 2002: 150f.

With respect to the distribution of existential and universal readings, Kanazawa notes that the effect of the determiner *every*, at least relative to other determiners like

*most*, *no*, and *at least two*, is to make the  $\forall$ -reading more readily available. In fact, his sense is that sentences with *every* have a default preference for the  $\forall$ -reading, though he acknowledges that there are clear examples of the  $\exists$ -reading with *every* as well. As for the determiners *no*, *some*, *several*, and *at least n*, he claims that they have only  $\exists$ -readings. In a static framework, the difference between these quantifiers and *every* can be characterized in terms of their monotonicity conditions (Barwise & Cooper 1981): *every* is downward monotone on its restrictor but upward monotone on its nuclear scope; *no* is downward monotone on both sides; and *some* and *at least two* are upward monotone on both sides. Based on these and other examples, Kanazawa claims that all other things being equal, the availability of  $\exists$ -readings and  $\forall$ -readings of donkey sentences headed by a determiner is systematically related to the monotonicity properties of that determiner.

While the strength of these defaults, especially the  $\exists$ -reading preference for *no*, has not gone unchallenged, our analysis can make sense of these preferences. We propose that donkey sentences often appear to have a default reading because sentences presented in absence of any clues as to what the QUD might be are typically interpreted as if they had been uttered in what we call a fact-finding context. For us, a fact-finding context for a sentence *S* is a context that is focused on truth simpliciter; that is, it is a context whose QUD is such that for all *w* and *w'*, if  $S(w) = \mathbf{true}$  and  $S(w') = \mathbf{neither}$  then  $w \not\approx w'$ . Our notion of a fact-finding context is inspired by what Roberts 2012 calls the Big Question (“What is the way things are?”) and what van Rooij 2003 calls “What is the world like?”; see also Malamud 2012. The Big Question, a partition in which each cell contains just one possible world, is an extreme case of a fact-finding context. A donkey sentence that is interpreted in a fact-finding context will always be interpreted as having a homogeneous reading. For donkey sentences headed by *every*, this is the  $\forall$ -reading. This accounts for Kanazawa’s generalization that the default interpretation of a determiner that is downward monotone on its restrictor and upward monotone on its nuclear scope is the  $\forall$ -reading.<sup>13</sup>

We can also make sense of another generalization proposed by Kanazawa, namely that determiners that are downward monotone on both their restrictor and their nuclear scope (such as *no*, *few*, and *at most n*) only have the  $\exists$ -reading.<sup>14</sup> This follows immediately from assuming that the default context is fact-finding, because fact-finding contexts give rise to  $\exists$ -readings for these kinds of determiners. Kanazawa

13 Kanazawa 1994 extends this generalization to determiners such as *not every* and *not all* that are upward monotone on their restrictor and downward monotone on their nuclear scope. We discuss these determiners in Section 6.3.

14 Kanazawa 1994 extends this generalization to determiners that are *upward* monotone on both their restrictor and their nuclear scope, and his formal account further generalizes it to all intersective determiners. We discuss these determiners later in this section.

discusses exceptions from this generalization; on our account, such exceptions are expected in non-default (that is, non-fact-finding) contexts. The sentences in (30) are precisely this kind of exception:

- (30) a. No man who had a credit card failed to use it.  
b. Not all students who borrowed a book from Peter returned it.

In virtue of world knowledge and their truth conditions, these sentences make QUDs salient that are not fact-finding, such as: *Did every card-owner pay by card?* and *Did Peter get all of his books back?* For both sentences, to the extent that intuitions are clear, the  $\forall$ -reading is the most prominent, as noted in Kanazawa 1994.

While our proposal that default readings of donkey sentences arise from fact-finding contexts is novel, the idea that special contexts can override default readings of donkey sentences is not new. It is illustrated by the following example, which Kanazawa 1994 attributes to David Beaver (p.c.):

- (31) A: John has a silver dollar. He didn't put it in the charity box.  
B: No, everybody who had a coin put it in the box.

While B's response is similar to the quarter sentence in (5b), which is a classic example of the  $\exists$ -reading, Kanazawa notes that the context created by A's utterance makes the  $\forall$ -reading of B's response the only sensible interpretation.<sup>15</sup> This makes sense on the present account if we assume that the discourse in (31) is naturally interpreted as a joint attempt to resolve a QUD such as *Did anybody keep any of their coins?* More generally, we can recast questions about the availability of various readings as questions about the availability of various QUDs. This can shed light on certain examples raised by Kanazawa that appear to resist modification by context. For example, as he notes, (32) does not have the  $\exists$ -reading, even though the surrounding material supports it and it is the weakest way for B to contradict A.

- (32) A: John doesn't have any quarters. He used all his quarters to buy a Coke.  
B: No, everybody who had a quarter kept it, so he must have at least one quarter left.

Our account makes sense of this on the assumption that the dispute between A and B initially concerns the QUD *Did John use all his quarters?*, which speaker B

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<sup>15</sup> Barker 1996 provides a similar example, a tweak on the classic quarter example, shown in (i), which prefers the  $\forall$ -reading for contextual reasons. In particular, the question of whether the meter is fed does not apply to slot machines, and so the  $\forall$ -reading emerges.

- (i) *Scenario:* We are talking about the behavior of men in gambling casinos.  
Usually, if a man has a quarter in his pocket, he will put it in the slot machine.

addresses by answering the stronger QUD *Which quarter-owners, if any, used all their quarters?*. Against this stronger QUD, B's utterance in (32) is expected to have the  $\forall$ -reading because it resolves the QUD in the same way whether the semantics assigns it **true** or **neither**. That is to say, as long as every quarter-owner kept at least one quarter, it already follows that none of them used all their quarters; and this remains the case regardless of how many quarter-owners kept all their quarters.

There is a conceptual difference between our account and that of Kanazawa 1994. We have accounted for the fact that a donkey sentence is readily judged true just in case both its  $\exists$ -reading and its  $\forall$ -reading are true, and false just in case both of them are false, by assuming that determiners are lifted into a dynamic framework via the type shifter  $\mathfrak{D}$  in (21). Of course a different type shifter would have led to different predictions; for example, we could have defined  $\mathfrak{D}$  based on some Boolean combination of  $\mathfrak{E}$  and  $\mathfrak{A}$  other than the one we actually used. Reasoning about analogous possibilities of arbitrariness and stipulation, Kanazawa (1994) justifies his choice of dynamic coercion operations in terms of the monotonicity properties of the embedding determiners. Specifically, Kanazawa claims that his interpretive principles reflect a tendency for donkey sentences to preserve valid inferential patterns that result from properties such as monotonicity and conservativity of non-donkey sentences and their underlying static determiners. Based on this, he suggests that the interpretation of donkey sentences can also be characterized implicitly by various conditions that formalize this tendency, and without resorting to his explicit interpretive principles. For example, on his view, the process that maps static determiners to dynamic determiners should guarantee that monotonicity inferences such as the following are valid by default.

- (33) Every farmer who owns a donkey beats it.
- a. So, every farmer who owns a female donkey beats it.
  - b. So, every farmer who owns and feeds a donkey beats it.

The problem with this view is that there are clear counterexamples to these inference patterns. Once  $\exists$ -readings of donkey pronouns are taken at face value, restrictors of universal quantifiers are no longer downward monotone. For example, imagine that a funeral took place in a small college town. All the townsmen showed up, and they all appropriately dressed in black suits except for a few college students who do not own suits. Imagine also that a number of townsmen own other suits that they did not wear to the funeral. For example, some townsmen also own tan suits, and

some others own suits that they misplaced. Then (34) is true while (34a) and (34b) are both false. Thus, the inference from (34) to (34a) and (34b) is invalid.

- (34) Every townsman who owns a suit wore it at the funeral.
- a. So, every townsman who owns a tan suit wore it at the funeral.
  - b. So, every townsman who owns and misplaced a suit wore it at the funeral.

The difference between the valid inference in (33) and the invalid inference in (34) suggests that the inference pattern is context-dependent; thus, it does not provide evidence about semantic validity. While Kanazawa (1994) might see cases like (34) as mere exceptions to a general tendency of preservation of inferential patterns, other examples like it can be easily constructed. This weakens the motivation for his account: indeed, on his proposal it would be unclear why these examples are not semantically valid independently of context.

While there is reason to doubt the underlying generalization Kanazawa posits and thus the explanation he offers for it, the question itself remains: why is the  $\mathcal{D}$  type shifter as we defined it the operative one in natural language? To answer this question, we note that  $\mathcal{D}$  arises naturally from a supervaluationist view on generalized quantifiers (van Eijck 1996). This in turn is a natural extension of the original supervaluationist treatment of truth-value gaps in van Fraassen 1969. As noted in Section 5, empirical motivation comes from the experimental results in Križ & Chemla 2015. A supervaluationist generalized quantifier such as *every man who owns a donkey* behaves just like its static counterpart whenever its nuclear scope denotes a classical predicate (e.g., *is French*); but when it is given a nonclassical predicate whose interpretation depends on the context, it returns *definitely true* whenever every precisification of the predicate makes the classical quantifier true, *definitely false* whenever every precisification of the predicate makes the classical quantifier false, and *neither true nor false* in all other cases. We treat irreducibly dynamic predicates such as *beats it* as nonclassical and as having two different precisifications: one is obtained by applying  $\mathcal{E}$ , and the other one by applying  $\mathcal{A}$ .<sup>16</sup>

Finally, the present theory parts ways with Kanazawa's in its treatment of donkey sentences with intersective quantificational determiners such as *some*, *at least n*, and *no*, which he claims only have the  $\exists$ -reading. The account here predicts that their interpretation will depend completely on the QUD. Now, while  $\forall$ -readings are

<sup>16</sup> There are clear parallels between our account and supervaluationist treatments of vagueness, such as Fine 1975. However, we do not see donkey sentences as vague because they do not give rise to the sorites paradox. On our account, the formal difference is that a predicate such as *beats it* has just two precisifications, while a vague predicate like *tall* has an unbounded number of precisifications.

difficult to observe in intersective determiners, some examples have already been noted in the literature:

- (35) At least one boy who had an apple for breakfast didn't give it to his best friend. (Chierchia 1995: 65)<sup>17</sup>
- (36) No man who had a credit card failed to use it. = (30)
- (37) No man who has an umbrella leaves it home on a day like this. = (5c)

Why, then, do Kanazawa (1994) and some other authors assume that intersective determiners can only have the  $\exists$ -reading? One reason may simply be the fact that relevant examples are hard to find (Geurts 2002: 131). Scenarios that give rise to  $\forall$ -readings in donkey sentences with upward monotone embedding determiners need to be carefully constructed, and it is easy to overlook their existence unless one specifically tries to find them. Another reason may be the role of negation. Geurts (2002), who considers (35) and (36), comments that such examples should not be taken at face value because they always seem to involve some kind of negation, and because negative sentences are often interpreted by removing the negation before evaluation and flipping the resulting truth value afterwards. That may be true for the examples Geurts is considering, but for the following examples it is less clear. Our scenarios are constructed to rule out uniqueness, so that the  $\exists$ -reading and the  $\forall$ -reading do not coincide.

- (38) *Scenario:* To follow the traffic laws, drivers need to put exactly one dime into the parking meter. Some drivers have more than one dime in their pocket, but nobody overpays.  
*QUD:* Did everyone follow the traffic laws?
  - a. Yes, every man who had a dime put it in the parking meter.
  - b. No, at least one man who had a dime kept it in his pocket.
  - c. No, one man who had a dime kept it in his pocket.

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<sup>17</sup> Chierchia attributes this example to van der Does 1993, where it appears as *A boy who had an apple in his rucksack didn't give it to his sister.*

- (39) *Scenario*: Carrying an umbrella allows you to stay dry. Some people own more than one umbrella, but in that case they take just one of them along and leave the other ones at home.  
*QUD*: Did any umbrella-owner get wet on this rainy day?
- No, every man who had an umbrella took it with him today.
  - Yes, at least two men who had an umbrella left it at home today.
  - Yes, two men who had an umbrella left it at home today.
- (40) *Scenario*: To enter the secret society's meeting, you need to remember password 1 or password 2. Most new members are given just one of the passwords, but some are given both.  
*QUD*: Was any member unable to access the meeting?
- No, every man who had been given a password remembered it.
  - Yes, at least one man who had been given a password forgot it.
  - Yes, one man who had been given a password forgot it.

In all of these examples, the a. sentences have the  $\exists$ -reading and the b. and c. sentences have the  $\forall$ -reading as their preferred interpretation.<sup>18</sup> In line with Yoon 1996, these examples have been constructed from pairs of opposite predicates. It would be difficult to claim that one of these predicates but not the other contains an implicit negation (though see Brasoveanu 2008: 178 for a different perspective), because the choice seems arbitrary in certain cases. For example, to remember is to not forget, and to forget is to not remember.

The embedding determiners in b. and c. are both intersective and upward monotone on both arguments. The monotonicity principle in Kanazawa 1994 predicts that determiners that are upward monotone on both arguments prefer the  $\exists$ -reading, and an additional principle he postulates, which he calls the Intersection Principle, ensures that intersective determiners do not generate the  $\forall$ -reading. As noted by Yoon (1996) and King & Lewis (2016: n. 30), this latter principle cannot hold in a categorical way, given that *no* is intersective yet clearly receives the  $\forall$ -reading in sentence (37). The b. and c. sentences in (38) through (40) make the same point for other intersective determiners. This shows that intersective donkey sentences can allow  $\forall$ -readings in contexts where the entire model is relevant. That said, a weakened version of the Intersection Principle that results from ignoring irrelevant individuals is consistent with our theory and has been argued to be psychologically plausible (Geurts 2002). See Section 6.3 for more discussion of this point.

<sup>18</sup> We account for the  $\forall$ -readings of the b. and c. examples by assuming that modified and bare numerals have static lexical entries (as listed in Table 1) that are type-shifted by  $\mathcal{D}$ .



## 6.2 Barker 1996

Barker 1996 shares many aspects and predictions of the present theory and has in part inspired it. However, it only briefly touches on donkey sentences headed by determiners. The main focus is on adverbial donkey sentences, such as these:

- (41) a. Usually, if a woman owns a dog, she is happy.  
 b. Usually, if an artist lives in a town, it is pretty.  
 c. Usually, if a linguist hears of a good job, she applies for it.

Following earlier work, Barker distinguishes between symmetric and asymmetric interpretations of donkey sentences. Sentence (41a) is naturally understood as making a claim about how many dog-owning women are happy. If a woman owns more than one dog, she is counted only once. Barker refers to this as a subject-asymmetric reading. Sentence (41b) is about the number of towns that have artists living in them (an object-asymmetric reading), and sentence (41c) is about linguist-job pairs (a symmetric reading). Barker's main claim is that asymmetrically interpreted adverbial donkey sentences come with a homogeneity presupposition:

- (42) *The homogeneity hypothesis* (HH, Barker 1996):  
 The use of a proportional adverbial quantifier when construed under a particular proportional reading presupposes that members of the same quantificational case all agree on whether they satisfy the nuclear scope.

Barker defines quantificational cases as equivalence classes of variable assignments that agree on what they assign to those variables that are bound by the adverbial quantifier. In (41a), each woman corresponds to a quantificational case. According to HH, (41a) presupposes that any woman is happy either about all of her dogs, or about none of them. Likewise, (41b) presupposes that any town is pretty or not no matter which artists live in it. No asymmetric readings are available for (41c), because the homogeneity presuppositions of these readings fail. In effect, homogeneity presuppositions neutralize the difference between  $\forall$ -readings and  $\exists$ -readings by ruling out any scenarios in which this difference could be observed.

Although HH is formulated so as to apply only to adverbial quantifiers, Barker tentatively assumes that it governs nominal quantifiers as well. If so, the subject-asymmetric reading of example (43) presupposes that every man who owns several donkeys beats all or none of them.

- (43) Most men who own a donkey beat it.

HH differs from the present account in that it predicts a presupposition failure for all those cases in which we assume a donkey sentence that is not literally true can

be “true enough”. An obvious challenge for HH arises from heterogeneous readings. Take sentence (5b), repeated here:

(44) Usually, if a man has a quarter in his pocket, he will put it in the meter.

Our account predicts that the sentence has these truth and falsity conditions:

- (45) a. **true** iff most quarter-owning men put all their quarters into the meter  
b. **false** iff most quarter-owning men put none of their quarters into the meter  
c. **neither** otherwise; for example, if every quarter-owning man puts exactly one quarter into the meter, and most of these men have additional quarters that they hold on to

Let  $w_{true}$ ,  $w_{false}$ , and  $w_{mixed}$  be worlds described by (45a), (45b), and (45c) respectively. Suppose that the QUD is whether most men who have a quarter follow the law by putting at least one quarter into the meter. This is the case both at  $w_{true}$  and at  $w_{mixed}$ . Hence (44) is true enough at  $w_{mixed}$ , and the present account will correctly predict that (44) on its asymmetric reading is interpreted heterogeneously as  $\{w_{true}, w_{mixed}\}$ , the  $\exists$ -reading.

By contrast, HH as presented so far wrongly rules out the asymmetric  $\exists$ -reading due to presupposition failure at  $w_{mixed}$ . Barker is aware of this and assumes that contextual domain narrowing prevents this presupposition failure by removing those quarters from consideration that remain in a man’s pocket at  $w_{mixed}$  after the parking laws have been satisfied. While Barker proposes no formal theory of domain narrowing, the general idea is that any entities that do not settle the QUD can be removed from the domain. In the restricted domain, the homogeneity presupposition is satisfied, and (44) is predicted true.

In the absence of an explicit theory of domain narrowing, it is difficult to find examples for which Barker 1996 and the present account differ clearly in their predictions. That said, our theory is not merely a formalization of HH. The two theories differ in how heterogeneity arises. In particular, Barker assumes that homogeneity is a presupposition and that domain narrowing is always available to rescue sentences from presupposition failure; but this does not always seem to be the case, as the following example shows (a variation of an example attributed to Barbara Partee in Heim 1982):

(46) #I dropped ten marbles and found only nine of them. The marble I dropped is under the sofa.

In this example, the definite description *the marble I dropped* cannot refer anaphorically; the fact that it is ruled out indicates that its uniqueness presupposition is not

satisfied either. If domain narrowing was available, we would expect it to rescue the example by removing the nine marbles the speaker found, so that the uniqueness presupposition is satisfied.

By contrast, the present account does not treat donkey sentences as presuppositional and need not appeal to domain narrowing. While we cannot directly compare our approach to HH without an explicit theory of domain narrowing, we do think there are reasons to prefer our account. In particular, HH is tailored to donkey sentences and does not seem to apply elsewhere, while the core ingredients of our account are independently motivated by analyses of plural definites (i.e., Križ 2016).

### 6.3 Geurts 2002

Geurts 2002 experimentally investigated the behavior of donkey sentences embedded by the four Dutch determiners *iedere* ‘every’, *niet iedere* ‘not every’, *enkele* ‘some’ and *geen* ‘no’ in mixed scenarios. Twenty native speakers were given truth value judgment tasks consisting of donkey sentences with pictorial representations. Aside from true and false, participants were also given a third option in case they could not make up their minds, but this option was almost never chosen. Geurts also varied the scenarios and sentences with an eye towards whether the embedding determiner combined with a “prototypical” concept such as *boy*, or with a “marginal” concept such as *railway line*, in the sense that the more marginal a concept is, the more leeway there is in individuating its tokens. For example, *railway line* is marginal because the Amsterdam-Brussels and the Brussels-Paris connection may be considered either two railway lines (we will call this the “split” interpretation) or parts of one and the same line, the Amsterdam-Paris line (the “joint” interpretation). Geurts found that sentences embedded by *some* were almost always judged true (suggesting the  $\exists$ -reading), and those embedded by *no* were almost always judged false (suggesting the  $\exists$ -reading as well), independently of differences in prototypicality. In the case of *every*, participants’ responses slightly tended towards the  $\exists$ -reading for more prototypical individuals and strongly tended towards the  $\forall$ -reading with more marginal individuals. The results for *not every* pattern exactly the opposite way as those for *every*.<sup>19</sup>

Geurts 2002 argues that mixed scenarios trigger what he terms an “interpretive crisis” and that hearers resolve it using different strategies, such as declaring the

19 The symmetry between *every* and *not every* is striking, and would be predicted by an extension of our account that lets *not* apply to the output of the pragmatic module. Transcripts from think-aloud sessions in a pretest suggested that at least one interpretive strategy that was used for sentences with *not every* consisted in evaluating the sentence without *not* and then flipping the result; see also Krifka 1996 for the related view that sentences of the shape *not every A is a B* are primarily used to deny universal claims to the effect that *every A is a B*. The think-aloud sessions lead Geurts 2002 to caution against taking judgments for donkey sentences with negation at face value.

sentence infelicitous, shifting from a “joint” to a “split” interpretation where possible, or using plausibility considerations to remove individuals from the domain. Our proposal can be seen as adding a strategy to this list: resolve the truth-value gap by using the QUD.

With respect to the effect of marginal individuals, Geurts 2002 convincingly argues that they are readily viewed as several “cases”. Thus the “split” interpretation of a sentence like (47a) can be paraphrased as in (47b).

- (47) a. Every railway line that crosses a road goes over it.  
 b. In every case where a<sup>1</sup> railway line crosses a<sup>2</sup> road, it<sub>1</sub> goes over it<sub>2</sub>.

In (47b), the  $\exists$ -reading and the  $\forall$ -reading coincide, and they are both equivalent to the  $\forall$ -reading of the “joint” interpretation of (47a). In this sense, “split” interpretations are a confound that is caused by marginal individuals and that causes spurious  $\forall$ -readings to appear. Most of the examples we discuss in the paper involve prototypical individuals such as farmers and townsmen; we therefore expect to have avoided this confound.

One of Geurts’s findings is that among the donkey sentences that he tested, those with *some* and *no* robustly get  $\exists$ -readings independently of whether the individuals were prototypical or marginal. In view of examples like (35) and (36), he concedes that it may be an overstatement to claim that these determiners only lead to  $\exists$ -readings, but he suggests that there is a distinct asymmetry between donkey sentences with such determiners on the one hand, and those with universal determiners like (*not*) *every* and (*not*) *all*, on the other, in that only the latter readily give rise to  $\forall$ -readings.

Geurts explains this pattern by assuming that determiners like *some* can influence the way a scene is interpreted: as he puts it, because they are intersective, they “allow us to concentrate on positive evidence, and ignore all else”.<sup>20</sup> While stressing that he should not be taken to imply that hearers have one strategy for verifying universal sentences and another one for existential sentences, he proposes in effect that intersective determiners may under certain circumstances be interpreted on submodels of the model in question. If they are judged true in the submodel, this can replace whatever truth value they might have in the entire model. For example, Geurts suggests that in a context he describes as in (48a), it is psychologically natural to understand (48b) as true:

20 Although Geurts focuses on the determiner *some*, he intends his reasoning to apply to other weak determiners as well, including, *mutatis mutandis*, to *no*. By weak determiners, he means intersective determiners like *some*, *a few*, *at least n*, *at most n*, (*exactly*) *n*, *no*, and possibly also *few* and *many*. Because the submodel selection procedure described in this subsection is only available for intersective determiners, it differs from domain narrowing as understood, for example, by Barker (1996), which is supposed to be available for all quantifiers.

- (48) a. *Context:* We have 4 boys altogether; 1 boy is standing alone; 1 boy is standing next to 1 girl and not holding her hand; 1 boy is standing next to 1 girl and holding her hand; 1 boy ('Fred', to give him a name) is standing between 2 girls, holding hands with 1 of them but not with the other ('Mary').
- b. Some of the boys that stand next to a girl hold her hand.

The relevant submodel here consists of all the boys and girls in (48a) except for Mary. While in the original model (48a) including Mary, the  $\forall$ -reading of (48b) is false and its  $\exists$ -reading is true, in the submodel without Mary both readings are true.

Now, Geurts' claim entails that in situations where we can ignore parts of a model while we interpret an intersective determiner, it is unobservable whether that determiner gives rise to the  $\forall$ -reading or the  $\exists$ -reading on the original model. This claim is compatible with the theory presented here, as well as with other theories. If correct, it may be one of the factors that explain why  $\forall$ -readings are hard to observe in intersective determiners, as we noted in Section 6.1.

#### 6.4 Brasoveanu 2008

Brasoveanu 2008 argues that an account of anaphora and quantification requires a richer notion of information state than that provided by assignments in ordinary dynamic semantics or compositional DRT. He introduces PCDRT, a system in which information states are sets of assignments rather than just assignments, and motivates it in part by donkey sentences with multiple instances of donkey anaphora such as the following:

- (49) Everyone who buys  $a^d$  book online and has  $a^e$  credit card uses  $it_e$  to pay for  $it_d$ .
- (50) Every boy who bought  $a^d$  Christmas gift for  $a^e$  girl in his class asked her  $e$  deskmate to wrap  $it_d$ .

Brasoveanu proposes that indefinites are ambiguous between a maximal or "strong" and a non-maximal or "weak" interpretation. When embedded under *every*, donkey pronouns whose antecedents are maximal give rise to the  $\forall$ -reading, while those whose antecedents are non-maximal give rise to the  $\exists$ -reading. For example, in (49), the indefinite *a book* is easily understood as maximal and the indefinite *a credit card* as non-maximal; in (50), the indefinites *a Christmas gift* and *a girl* are both strong. Formally, Brasoveanu models the weak-strong distinction as a lexical ambiguity. Maximal indefinites simultaneously introduce as many values as possible, while non-maximal indefinites are free to assign a smaller set. For example, the assignments in any output state of  $a^d$  donkey map  $d$  to farmer-owned donkeys. If  $a^d$

is maximal, these assignments do this in such a way that no farmer-owned donkey is left out. If  $a^d$  is non-maximal, among the output states of the indefinite there will be some whose assignments leave out some donkeys. Pronouns check that all assignments in their input state agree on the value of their discourse referent.

In [Brasoveanu 2008](#), the main purpose of this ambiguity is to account for the  $\exists/\forall$  dichotomy. However, [Brasoveanu 2008](#): 164 points out that having two indefinites in the grammar predicts a subtle ambiguity even outside of quantificational contexts. For example, a discourse like *A<sup>d</sup> man came in. He<sub>d</sub> sat down.* is predicted to be ambiguous between *There is a man who came in and who sat down* and *Exactly one man came in, and he sat down.* The uniqueness inference in the latter reading arises from the interaction of the maximal indefinite and the uniqueness condition of the pronoun. For that reason, if the singular pronoun is swapped out for a plural one, it is incorrectly predicted that *A<sup>d</sup> man came in. They<sub>d</sub> sat down* will be true whenever every man who came in sat down. [Brasoveanu 2008](#): n. 40 speculates that such a sentence may be ruled out for independent reasons related to agreement or presupposition maximization.

In addition to sidestepping these worries about overgeneration in non-quantificational contexts, our analysis offers a more parsimonious treatment of donkey ambiguities than the account in [Brasoveanu 2008](#). In particular, we have shown that in the presence of a pragmatic theory such as the one we have adopted, one can analyze most if not all phenomena involving donkey anaphora with ordinary assignments as in CDRT, without having to manipulate sets of assignments as in PCDRT. Because we delegate the work of resolving the  $\exists/\forall$  dichotomy to the pragmatics, we no longer require the semantics to model any ambiguity at the level of either the pronouns or the indefinites. This allows us to rely on a relatively simple semantic theory, specifically, the version of CDRT introduced in [Muskens 1995](#). There are certainly arguments for PCDRT which we have not addressed here because they go beyond donkey sentences; in particular, PCDRT has been partly motivated by the need to capture quantificational dependencies for the purpose of plural pronominal anaphora ([Brasoveanu 2008](#)) and quantificational and modal subordination ([Brasoveanu 2010](#)). Our work shows that the variety of readings available for donkey anaphora does not by itself necessitate a move to sets of assignments.

## 6.5 [Brasoveanu 2010](#)

While the main focus of [Brasoveanu 2010](#) is on the truth-conditional and anaphoric components of quantificational and modal subordination, the paper also contains a discussion and an implementation of donkey anaphora. [Brasoveanu 2010](#) treats indefinites as ambiguous, but takes a different route than [Brasoveanu 2008](#) did. Indefinites can still introduce their own discourse referents; when they do, they

are always interpreted non-maximally, resulting in existential readings. To model universal readings, Brasoveanu now assumes that an indefinite can be translated identically to an anaphoric definite. In that case, instead of introducing a novel discourse referent, the indefinite picks up a previously introduced discourse referent. Embedding determiners are given the ability to introduce additional discourse referents; Brasoveanu 2010 assumes that these are the only discourse referents that indefinites can pick up. As he notes, this move is in the spirit of Dekker 1993; the necessary adjustments to the translations of embedding determiners make them multiply selective instead of singly selective. Simplifying somewhat, the LFs for the existential and universal readings of sentence (9) are assumed to be as follows:

- (51) a. Every<sup>f</sup> farmer who owns a<sup>d</sup> donkey beats it<sub>d</sub>. *existential reading*  
 b. Every<sup>f,d</sup> farmer who owns a<sub>d</sub> donkey beats it<sub>d</sub>. *universal reading*

The multiply selective quantifier *every<sup>f,d</sup>* in (51b) quantifies in effect over farmer-donkey pairs; the indefinite *a<sub>d</sub> donkey* receives the same interpretation as the anaphoric definite *the<sub>d</sub> donkey* would.

One downside to this approach is that since indefinites and definites share a reading, any distributional differences between them must be stipulated and cannot be explained in semantic terms. For example, a stipulation is required to rule out discourse-initial sentences like the following:

- (52) Every<sup>f,d</sup> farmer who owns the<sub>d</sub> donkey beats it<sub>d</sub>.

If the definite were able to pick up the discourse referent *d* introduced by the embedding determiner, the resulting reading would be indistinguishable from the  $\forall$ -reading in (51b).

A more general problem with approaches that locate the ambiguity in the indefinite arises from mixed existential-universal sentences in which the same indefinite antecedes two pronouns:

- (53) Every man who has an umbrella takes it along on rainy days but leaves it home on sunny days.

On the most natural reading of this sentence, what is required for its truth is for every umbrella-owner to take one umbrella along when it is raining, and to leave all of his umbrellas at home when the sun is shining. In other words, the first donkey pronoun is naturally interpreted existentially and the second one universally. Now consider a situation in which every man owns two umbrellas, so that the two readings do not collapse. No matter if the antecedent is interpreted strongly or weakly, one of the pronouns will be assigned the wrong meaning on both Brasoveanu 2008 and Brasoveanu 2010.



On the present account, the ambiguity is located in the pragmatics, and generating the plausible reading poses no particular problem. The semantics treats sentence (53) as true only if every umbrella-owner takes all his umbrellas with him when it is rainy (even though one would suffice to stay dry). While this is not the case in the situation of interest, a QUD such as *Did everyone stay dry when it rained and unburdened when it was sunny?* will lump this situation together with those where everyone took multiple umbrellas with them, as desired.

## 6.6 Champollion 2016

With essentially the same goals in mind as in the project here, *Champollion 2016* — a precursor of the current work — sketches a dynamic fragment intended to generate effective truth-value gaps for donkey readings in mixed scenarios. But where the current approach fairly directly lifts *Križ’s (2016)* semantic clauses into a simple compositional dynamic framework (that of *Muskens 1995*), *Champollion 2016* leans on the PCDRT framework of *Brasoveanu 2010*, augmented with designated “error” referents/objects, together with explicitly supervaluationist lexical entries for determiners.

As we have seen in Section 6.4, the full power of PCDRT is not needed for our purposes. In addition, the specific setup in *Champollion 2016* leads to several empirical issues. First, *Champollion 2016* relies on the strong (maximal) entry for indefinites proposed in *Brasoveanu 2008*. This of course inherits the difficulties mentioned in Section 6.4 above when indefinites appear outside of quantificational contexts. For instance, given the maximality of  $a$ , the assignments coming out of sentence (54a) will contain, between them, as many sandwiches as were eaten by students. The subsequent pronoun ought then to be able to refer to this discourse plurality, as it can in (54b), but this is impossible.

- (54) a. A student ate  $a^d$  sandwich. #They<sub>d</sub> were tasty.  
 b. Every student ate  $a^d$  sandwich. They<sub>d</sub> were tasty.

*Brasoveanu 2008* could at least avoid this possibility in principle by stipulating that indefinites outside the arguments of generalized quantifiers are necessarily interpreted weakly (non-maximally). But since *Champollion 2016* is in part motivated by a desire to avoid semantic ambiguity in the elements that comprise donkey sentences, it is committed to a single maximal indefinite everywhere.

Second, *Champollion 2016* assigns to the singular donkey pronoun a meaning that tests the outputs of its local update for uniformity with respect to a certain discourse referent. For instance, in the sentence *Every<sup>f</sup> farmer who owns  $a^d$  donkey beats it<sub>d</sub>*, the pronoun will be in charge of inspecting whether the discourse referent  $f$  associated with the subject of the predicate *beats* — which will in each distributive

cycle refer to some particular donkey-owning farmer — behaves uniformly with respect to the values stored in the discourse referent  $d$  — which will pick out all of the donkeys owned by whoever the particular farmer of the moment is. In other words, when considering farmer John,  $it_d$  will test the incoming sets of assignments to make sure that John beats either all or none of the donkeys injected by the maximal  $a^d$ .

To make this work, the pronoun must take scope over the predicate that it uses as the basis of its uniformity test. In the presence of scope islands, this leads to both under- and over-generation issues.<sup>21</sup> Consider the sentence in (55):

- (55) Every student who brought a<sup>d</sup> backpack got in a fight with somebody who insulted  $it_d$ .

Its  $\forall$ -reading, for example, is true just in case every student  $x$  defended the honor of each of  $x$ 's backpacks. The property that  $it_d$  would need to test for uniformity in this case is the entire nuclear scope of the quantifier: the property of getting in a fight with somebody who insulted  $d$ . But since the pronoun is embedded in the relative clause island, it cannot take scope high enough to see all of this information. This is the undergeneration worry. The overgeneration worry is that instead, the pronoun *can* take scope just within the relative clause. But (55) has no reading which would correspond to the truth conditions obtained by throwing an error just in those cases where students' behaviors are mixed with respect to whether they were insulted; all of its readings ought to depend on whether students are mixed with respect to whether they got in fights with their insulters.

## 7 Conclusion

This work has shown that the apparent complexity of the  $\exists/\forall$  dichotomy in donkey sentences follows from the interaction of two relatively simple independently motivated formal systems: a pragmatic account of how context disambiguates plural definites and donkey sentences, and a lean dynamic semantics which abstains from drawing borders between true and false scenarios, and leaves truth-value gaps for the pragmatics to fill. As suggested by Yoon 1994, 1996 and Krifka 1996, we have given plural definites and donkey anaphora a uniform pragmatic treatment. Just as Križ 2016 treats *The doors are open* as *Things are equivalent for current purposes to the way they would be if all the doors are open*, we propose to treat the classical donkey sentence as *Things are equivalent for current purposes to the way they would be if every farmer who owns a donkey beat all the donkeys he owns*, modulo the contrary-to-fact implication that these paraphrases suggest. Our pragmatic account

<sup>21</sup> Thanks to Simon Charlow for pointing this out.

captures the exception tolerance of both plural definites and donkey sentences in a simple and uniform way.

To specify what it means to be equivalent for current purposes, we have modeled this notion as an equivalence relation between worlds that is left underspecified by the semantics and determined by the pragmatics. Following [Križ 2016](#), we have identified this equivalence relation with an implicit question that represents the overarching goal towards which the conversation participants are working; we have identified this implicit question with the QUD. This accounts for the fact that when the context, including the QUD, is fully specified and held fixed, a donkey sentence is not perceived as ambiguous between the  $\exists$ -reading and the  $\forall$ -reading. Because different donkey sentences are used in different conversational settings (or naturally evoke different settings when presented in isolation), the QUD may well vary from one donkey sentence to another. This explains why the  $\exists$ -reading and the  $\forall$ -reading can flip-flop when one switches between predicates like *open* and *closed* while keeping the context constant ([Yoon 1996](#)) and when one switches between contexts while keeping the sentence constant ([Gawron, Nerbonne & Peters 1991](#)). The pragmatic component of our account is broadly similar to [Barker 1996](#), but does not assume that donkey sentences involve a uniqueness or homogeneity presupposition and does not rely on a yet-unconstrained notion of domain narrowing.

By shifting some of the explanatory burden from the semantics to the pragmatics, we have avoided problems that arise from trying to make plural definites and donkey anaphora semantically uniform. In particular, [Yoon](#) and [Krifka](#) rely on the problematic assumption that *it* and *the donkey(s) he owns* can be given a parallel analysis in terms of plural individuals. This is problematic because, as [Kanazawa 2001](#) shows, plural individuals cannot be involved in the semantics of *it*. Our account avoids the need for plural individuals in the interpretation of singular donkey pronouns. That said, our account is fully compatible with assuming plural individuals as referents of *plural* donkey pronouns, as suggested by [Kanazawa 2001](#).

Our semantic component also allows us to keep the semantics streamlined to a fragment of CDRT ([Muskens 1995, 1996](#)). We have shown that accounting for the  $\exists/\forall$  dichotomy in donkey sentences does not require moving to systems that treat donkey anaphora in terms of evaluation-level pluralities and plural information states like those in [Brasoveanu 2008, 2010](#). By not relying on plural information states, we were able to avoid a number of empirical issues identified in [Champollion 2016](#), a precursor of the present work.

The system we have explored is theoretically parsimonious. Not only does it rely on lean and independently motivated components, it also avoids the need to postulate any sort of semantic ambiguity. This sets it apart from systems such as [Chierchia 1995](#), where the  $\exists/\forall$  dichotomy is attributed to an ambiguity of the donkey pronoun; [Kanazawa 1994](#), where it is modeled at the level of the embedding determiner; or

Brasoveanu 2008, 2010, where it is traced back to an ambiguity of the indefinite antecedent. Problems with the first and second types of systems have been laid out in Brasoveanu 2008: Section 6.1. As we have shown, the third type of system has problems with sentences like (53) in which the same indefinite serves as an antecedent to two donkey pronouns.

Finally, our account explains why hearers give varied and guarded judgments in mixed scenarios: these are precisely the scenarios in which the semantics does not deliver a definite truth value. The variation in judgments is traced to variation in QUDs, and the hesitation stems from hearers' reluctance to accommodate one of several possible QUDs when the common ground does not provide sufficient evidence to narrow down the choice between them.

We close by pointing out several new avenues of research that our investigation has opened up. First, there is an acute need for theories of how interlocutors jointly converge on QUDs. Our pragmatic account can be combined with such theories to make predictions about donkey sentences in context. More generally, theories of QUDs should address related questions such as how hearers accommodate QUDs in the face of incomplete information, and what is the role of question-answer congruence in this process. Relatedly, we have left open how to extend theories of question-answer congruence to the trivalent setting.

Although we have implemented our semantics in a dynamic fragment, we do not handle anaphora to maximal sets or evaluation pluralities; in particular, the  $\mathfrak{D}$  schema in (21) is externally static, so we have no account for discourses like *Every student read a<sup>d</sup> book; they<sub>d</sub> were all best-sellers*. In contexts where the truth value of a donkey sentence is **neither**, it is plausible that the same pragmatic factors that determine its truth value in context also influence which individuals — which donkeys, for example — the discourse referent of the embedding determiner makes available for anaphora in subsequent sentences. Like Križ (2016), we have assumed a globalist view of the semantics-pragmatics interface, in which there is a one-way information flow from the semantics to the pragmatics; but it would not be difficult to reformulate our account in localist terms so as to allow pragmatic intrusion into the compositional semantics (Levinson 2000, Chierchia, Fox & Spector 2011). For example, a localist version of our account could let  $\mathfrak{D}$  take the QUD as an additional argument and output a bivalent semantics, as well as determining the dynamic potential of the sentence. Such a model could also be helpful for the interpretation of embedded donkey sentences such as *If every student who took a class from me liked it, I will get a bonus* or — as argued in Section 6.3 — *Not every farmer who owns a donkey beats it*. Seen in this way, donkey sentences constitute a novel testing ground for the debate between localist and globalist accounts of the semantics-pragmatics interface.

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