Scalar Implicatures with Discourse Referents: A Case Study on the Plurality Inference of Plural Nouns*

Yasutada Sudo

December 7, 2020

Abstract

In this paper I will explore the hitherto unexplored idea that scalar implicatures are computed with respect to the anaphoric dimension of meaning, which is modeled in terms of *discourse referents*. It is widely agreed that discourse referents as carriers of anaphoric information need to be represented separately from truth-conditional meaning. Given Grice's insight that scalar implicature arise via alternatives that are more informative (or not less informative, under some theories), it is naturally expected that they should participate in the computation of scalar implicatures in addition to the truth-conditional meaning, but most of the literature on scalar implicature has so far ignored this possibility. I will give a formalisation of this idea using a version of dynamic semantics, and demonstrate its empirical usefulness by applying it to one phenomenon, the *plurality inference* of plural nouns in English.

1 Introduction

It is known that pronominal anaphora cannot be explicated solely by truth-conditions (Karttunen 1976, Kamp 1981, Heim 1982). This is most acutely shown by a pair of two sentences that have contextually equivalent truth-conditions but differ with respect to discourse anaphora. For instance, *it* can refer to Paul's Taxpayer Identification Number (TIN) in (1a), but not (1b), even if it is commonly known that every registered taxpayer has a unique TIN, and everyone who has a TIN is a registered taxpayer.

(1) a. Paul has a TIN. But he hasn't used it in a while.
b. Paul is a registered taxpayer. ??But he hasn't used it in a while.

*The first version of this work developed for the fifth meeting of London Semantics Day held at Queen Mary University of London on 15 May 2018, and since then I have had many occasions to discuss the present work at various institutions: Universiteit Utrecht (11 June 2018), Leibniz-Zentrum Allgemeine Sprachwissenschaft (15 June 2018), Ecole Normale Supérieure (21 March 2019), University of Vienna (20 May 2019), Heinrich-Heine-Universität Düsseldorf (26 June 2019), University of Oxford (5 June 2019), Goete-Uniersität Frankfurt (11 July 2019), Georg-August-Universität Göttingen (6 September 2019), University of Toronto (2 December 2019), Massachusetts Institute of Technology (6 December 2019), and the semantics seminar I co-taught with Gennaro Chierchia, Nathan Klinedinst, and Daniel Rothschild at University College London in Autumn 2019. I would like to thank the audiences of these events for comments, criticisms, suggestions, as well as encouragements. My special thanks go to Gennaro Chierchia, Kai von Fintel, Martin Hackl, Natalia Ivlieva, Filipe Kobayashi, Manuel Križ, Jeremy Kuhn, Matt Mandelkern, Rick Nouwen, Jacopo Romoli, Benjamin Spector, and Ede Zimmermann. I am solely responsible for any remaining errors.

In order to explain this difference, theories of discourse anaphora postulate *discourse referents*. Discourse referents are abstract semantic objects that can be introduced to linguistic discourse in certain specific ways, e.g. by using an indefinite noun phrase. They represent information about what kind of entities are being talked about, and by assumption, are essential in resolving pronominal anaphora. Putting aside all the formal details for now, this idea explains the above contrast as follows.[1] The first sentence of (1a) introduces a discourse referent representing Paul's TIN and the pronoun can be successfully resolved to it, while the first sentence of (1b) does not introduce a discourse referent, so the pronoun in the second sentence cannot be interpreted as Paul's TIN.

Although a number of different formal implementations of discourse referents have been put forward, it has been uncontroversially assumed that the semantic representations of sentences in natural language consist of (at least) two dimensions: discourse referents and truth-conditions.[2] Nevertheless, it is quite surprising to notice that potential implications of this multi-dimensionality of natural language semantics on pragmatic and other related phenomena have not been given enough attention in the theoretical literature, especially given that discourse referents have been in use for more than half a century by now. In this paper I will focus on *scalar implicature*, and examine what roles discourse referents can and should play in this phenomenon.

Scalar implicatures have been very actively studied since the 1970s, and consequently the literature is extremely copious, but discourse referents have been almost always ignored (rare exceptions include Geurts 2008, 2009, Sudo 2016).[3] I would say this negligence in the literature is unjustifiable, given that virtually all theories of scalar implicature, although technically and conceptually diverse, share the fundamental insight that goes back to Grice (1989), which roughly goes as follows: Sentence ϕ has a scalar implicature when it has an alternative ψ that is more informative (or is not less informative, according to some theories). In most current implementations of this idea, informativity is understood solely in terms of truth-conditions. That is, sentence ψ is said to be more informative than sentence ϕ, if whenever ψ is true, ϕ is true, but not vice versa. However, the idea of informativity is more general than just this, and applicable to any type of information. Since discourse referents represent information distinct from the truth-conditional aspect of meaning, it makes sense to talk about the informativity of

[1]The term *discourse referent* tends to be associated with (certain versions of) dynamic semantics, but the idea of discourse referents as carriers of anaphoric potentials is more general, and could be understood as encompassing certain versions of the E-type approach to pronominal anaphora (Elbourne 2005), as well as Stalnaker's (1989) suggestion for using possible worlds to explain discourse anaphora. I will discuss this point in greater detail in Section 3.1.

[2]Natural language semantics is often considered to be multidimensional in other respects as well. Most notably, so-called *expressive meaning* is often considered to be semantically independent from truth-conditions and the anaphoric dimension of meaning (Potts 2005, 2007). But some recent work on expressives (McCready 2010, Gutzmann 2015, Gutzmann & McCready 2016, among others) propose to blur the boundary between the expressive and truth-conditional dimensions, although that's not how these authors characterize their proposals. Presupposition is more controversial: while many regard presuppositions to be part of truth-conditions (Heim 1982, 1983, Beaver 2001, Beaver & Krahmer 2001, George 2008, Fox 2012), some argue that they should be treated as a separate dimension of meaning (Karttunen & Peters 1979, Sudo 2012, 2014). If either of these phenomena calls for a different dimension of meaning, their behavior in pragmatic inference should also be examined in detail. As far as I know, this topic has been unexplored.

[3]One of the prominent views of scalar implicature in the current theoretical literature is the so-called *grammatical approach*, according to which scalar implicatures are not pragmatic inferences in the classical sense of pragmatics as involving post-semantic reasoning about conservational intentions, but are actually generated by a phonologically silent linguistic operator (see Chierchia, Fox & Spector (2012) and references therein). However, it is still true that discourse referents have been largely neglected. A version of the grammatical approach to scalar implicature that makes reference to discourse referents will be presented in Section 4.3.

discourse referents introduced in ϕ and ψ. And if ψ introduces a more informative discourse referent than ϕ does, then it is expected that there will be some scalar implicature. This is exactly the idea that I would like to explore in this paper.

I will take one empirical phenomenon, namely, the plurality inference of plural noun phrases in English, as a case study, and claim that understanding the plurality inference as a scalar implicature involving discourse referents allows us to achieve a straightforward analysis of this phenomenon. I will offer one particular way of formalising this analysis in a (relatively plain) version of *dynamic semantics*. My choice of the framework is not theoretically crucial, but practically motivated. Arguably, the idea of discourse referents is most thoroughly formally worked out in dynamic semantics. Also, the fact that the interaction between quantification and discourse referents has been formalised quite extensively turns out to be an advantage of this framework for my purposes. I will remark on these points in more concrete terms as we go along.

Having set the goal, I should also concede at this point that the formal analysis put forward here will not give us a lot of extra empirical mileage in comparison to certain previous analyses of the same phenomenon, especially, Spector (2007), although towards the end of the paper, I will argue that my analysis allows for a new way of understanding an observation made by Crnič, Chemla & Fox (2015) about the so-called distributivity inference of disjunction under a universal quantifier (also discussed by Bar-Lev & Fox 2020). Also, needless to say, my analysis could well turn out to be on the wrong track for this particular phenomenon. Despite these caveats, the formal theory presented here has indepedent theoretical value as a proof of concept for the idea of scalar implicatures with discourse referents, since, as remarked above, as long as we stand on Grice's insight, discourse referents must be relevant for scalar implicatures, and this is the first systematic study to explore this idea.

The present paper is organised as follows. In Section 2, I will review the main empirical phenomenon, the plurality inference of plural nouns phrases in English, and sketch the proposal in informal terms. After introducing a simple dynamic semantic system in Section 3, I will show a concrete formal implementation of the analysis of the plurality inference with details of how scalar implicatures are to be computed with respect to discourse referents in Section 4. Then in Section 5, I will extend the analysis to cases involving quantifiers by implementing externally dynamic selective generalised quantifiers, and discuss a consequence of this extension on the distributivity inference of disjunction under a universal quantifier in Section 6. Finally I will conclude in Section 7.

2 Plurality inference

Terminologies used in linguistics can be misleading. The label *plural* for certain forms of nouns in languages like English is one good example. To illustrate, consider the following sentences.

(2) a. This coat has pockets.
    b. This coat does not have pockets.

A noun like *pockets* is standardly called plural, and this is presumably based on the fact that a sentence like (2a) has a very robust *plulality* inference that the coat in question has more than one pocket. However, what is surprising is that the negation of this sentence, (2b), does not mean the negation of (2a) with the plurality inference, which would be that the coat does not have multiple pockets. Rather, its meaning is stronger than this, namely, that the coat has no pocket whatsoever. In other words, the plural noun *pockets* in (2b) does not behave as it should, if it were semantically plural and behaved as expected from the compositional semantics. To put it another way, if a non-English speaking fieldwork linguist encountered (2b), but not (2a), their initial analysis would most likely be that *pockets* is number-neutral, rather than plural.[4]

An immediate question that the above contrast gives rise to is when a plurality inference is observed, and when it is not. As a number of previous studies point out, the generalisation is that bare plural indefinites like *pockets* give rise to number-neutral readings in negative contexts that largely overlap with NPI-licensing contexts. These include sentences with sentential negation like (2b) above, as well as those in (3).[5]

(3) a. If you have *coins* in your pocket, please put them in the tray.
b. We should clean up the mess before *guests* arrive.
c. This plant can survive without *leaves* for many years.

A number of different analyses have been proposed to account for the inconstant presence of the plurality inference. Here is a short summary of the current literature.

- The scalar implicature approach (Mayr 2015, Spector 2007, Ivlieva 2013, 2020, Zweig 2009) analyses the plurality inference as a scalar implicature.
- The ambiguity approach (Farkas & de Swart 2010, Grimm 2013, Martí 2018) postulates ambiguity between plural and number-neutral meaning.
- The homogeneity theory (Križ 2017) likens the semantic behaviour of bare plurals to that of definite plurals, which are known to exhibit homogeneity effects.
- The anti-presupposition approach (Sauerland 2003, Sauerland, Anderssen & Yatsushiro 2005) derives the plurality inference as an anti-presupposition.

Of these, the anti-presupposition approach is historically the oldest, but at least the versions proposed by Sauerland (2003) and Sauerland et al. (2005) are known to have a serious empirical

[4] As Spector (2007) points out, plural nouns under negation are actually not completely number-neutral, because otherwise the infelicity of (i) would be unexpected.

(i) #My son doesn't have Roman noses.

I do not think there is a very insightful account of this observation in the current literature. Spector (2007) mentions it as essentially an open problem for his account. Farkas & De Swart (2010) discuss it in some detail but do not give a satisfactory account. It seems to me that this is actually a probabilistic phenomenon in the sense that the anomaly of (i) comes from an inference that the probability (according to the common ground) of my son's having multiple noses is high, which accounts for the above anomaly. The reason why I think this inference is probabilistic is because of cases that do not have extreme probabilities. For example, consider (ii).

(ii) a. The postdoc will not submit an abstract to CUNY.
b. The postdoc will not submit abstracts to CUNY.

Both of these are acceptable sentences, but they are not completely equal. That is, if the probability of the postdoc submitting exactly one abstract is deemed high, (iia) is the more natural choice, but if it's more likely that they will submit multiple abstracts, (iib) sounds better. Furthermore, it seems that when judgments become sharper when the probability approaches either extreme. This aspect of meaning is highly intriguing but requires more careful empirical research, and since it is not immediately relevant for my purposes here, I will leave it for future research.

[5] Bare plurals in polar questions like *Does this coat have pockets?* are often mentioned in this connection, but their judgments seem to be more involved than usually assumed. In particular, whether the *yes*-answer is felicitous when the coat only has one pocket seems to be affected by extra-linguistic considerations as well, e.g. whether or not the speaker needs more than one pocket to achieve what they want to achieve. See Pearson, Khan & Snedeker (2010), Bale, Gagnon & Khanjian (2011) for discussion.

flaw with respect to quantification. As Spector (2007) discusses this problem in detail, I will not repeat it here. Among the other three, I will adopt the scalar implicature approach in this paper, because I believe its empirical coverage is broader than the other two, especially with respect to what I call the *partial plurality inference*. I will detail this point below, but I will do so without introducing technical details of the two alternative analyses. This is because the primary purpose of this paper is not to fully adjudicate between these different approaches to the plurality inference, but to demonstrate the relevance and potential empirical merits of the idea of scalar implicatures with discourse referents.

2.1 Partial plurality inference

There are two types of partial plurality inferences. The first kind, exemplified by (4), is discussed by Spector (2007) (see also Ivlieva 2014, Križ 2017).[6]

(4) Exactly one of these coats has pockets.

This sentence has a plurality inference, in the sense that the unique coat that has pockets has multiple pockets. However, this inference is only partially plural because with respect to the other coats, *pockets* is understood number-neutrally. That is, the sentence entails that these other coats do not have any pocket, rather than merely that they do not have multiple pockets.

The second kind of partial plurality involves a definite plural with a bound pronoun and is discussed by Sauerland (2003) and Sauerland et al. (2005). Consider (5), for example.

(5) Every passenger of this flight lost their suitcases.

This sentence has a presupposition that makes it infelicitous if every passenger has exactly one suitcase. Crucially, this presupposition does not require every passenger to have multiple suitcases, but rather only that at least some of the passengers have multiple suitcases. Thus, this plurality inference is in the presuppositional domain and is partial in the sense that it does not apply to every passenger.

Farkas & De Swart (2010:fn. 25) explicitly acknowledge that sentences like (4) pose a significant challenge for their ambiguity approach. They do not mention examples like (5), but

[6] In principle the same point could be made with a plural quantifier like *exactly two*, *an odd number of*, etc. but it would allow for a dependent plural reading of the plural object, which would muddle the judgments.

(i) Exactly two of my students wrote interesting papers.

As Ivlieva (2013, 2020) discusses in detail, dependent plurals give rise to very interesting issues. Above all, as she points out, they cannot be reduced simply to cumulative readings (*pace* Zweig 2009), as their distributions are different. Furthermore, Ivlieva (2014:fn. 2) points out that Spector's (2007) version of the scalar implicature approach fails to derive them straightforwardly. I believe my account of the plurality inference proposed has some bearing on how to explain dependent plurals, but I would like to address it in a separate paper, as we would need non-distributive quantifiers to give a complete account of dependent plurals, which would make this paper twice as long.

Another way to show the same issue is with a universal quantifier as in (ii).

(ii) Every coat has pockets.

As discussed by Spector (2007), Zweig (2009) and Križ (2017), this sentence seems to have a partial plurality inference that at least some of the coats have multiple pockets. However, arguably, it also has a reading that entails that every coat has multiple pockets, so the judgments are perhaps less clear (cf. Ivlieva 2020:fn. 32). I will discuss how my account derives the partial plurality inference in Section 5.4.

they are equally problematic. Here is why. The ambiguity approach postulates two meanings for each plural noun at the lexical level, a semantically plural meaning and a number-neutral meaning, and puts a constraint on their distributions so as to explain why simple sentences like (2a) and (2b) do not come out ambiguous. The problem is that under this view, there is no way to assign both plural and number-neutral meanings to one occurrence of a plural noun, but that is exactly what is needed to account for the partial plurality inferences. Other implementations of the ambiguity approach suffers from the same issue.

Križ's (2017) homogeneity approach assigns a trivalent meaning to sentences with bare plurals, as it does to sentences with definite plurals. For instance, (2a) will be true when the coat in question has multiple pockets and false when it has no pockets, and when it has exactly one pocket, it denotes a third truth-value. The negation just swaps the true and false conditions, so (2b) will be true when the coat has no pockets and false when it has multiple pockets. Thus, whenever it is true, it is entailed that the coat has no pocket whatsoever. In addition, it is assumed that pragmatic considerations sometime allow the third truth-value to be treated on a par with truth or with falsity.

Križ discusses how quantifiers behave in this trivalent system in detail. I will not delve into the details to save space, but essentially, (4) can be analyzed as follows. It is true when exactly one coat has multiple pockets and the other coats have no pockets, false in the following cases: (i) every coat is pocket-less, (ii) two or more coats have exactly one pocket, and (iii) two or more coats have multiple pockets. In all other cases, the sentence will denote the third truth-value. In all other cases, the sentence denotes the third truth-value. Thus, whenever the sentence is true, it is entailed that one coat has multiple pockets and all the other coats don't have any.[7] However, this account falls short of accounting for (5). Although Križ isn't explicit about presuppositions, assuming that the presupposition of (5) amounts to a universal statement that every passenger has suitcases, it predicts that this presupposition is true when every passenger has multiple suitcases, which is a full-blown plurality inference. The account could potentially also derive a weaker presupposition by treating the third truth-value on a par with truth, but this reading is too weak: The presupposition will be true when every passenger has at least one suitcase. The former might actually be a possible reading of the sentence (while the availability of the latter is questionable), but crucially, the analysis fails to account for the prominent reading of the sentence with a partial plurality inference.

This leaves us with the scalar implicature approach. As far as I know, this is the only approach that can deal with both types of partial plurality inference. However, it is considered that it requires certain additional assumptions for it to work. I will not delve into the technical bolts and nuts of different implementations of the scalar implicature approach, but I will point

[7] I am not certain if the predictions about the third truth-value for sentences (2b) and (4) are on the right track. This theory has a way to factor in pragmatic factors, as mentioned above, but it seems to me that the crucial assumption that definite and bare plurals behave similarly breaks down here. That is, while it seems reasonable to say that (ia) denotes the third truth-value when I bought exactly one of the coats, but it seems counter-intuitive to me to say that (ib) denotes the third truth-value when I bought exactly one coat. Note that these two sentences could be evaluated with respect to essentially the same pragmatic context.

(i) a. I didn't buy the coats.
    b. I didn't buy coats.

A similar issue arises with quantified sentences. For instance, (4) is predicted to be plainly false when more than one coat has exactly one pocket or more than one coat has multiple pockets (as well as when none of the costs has any pocket), but denote the third truth-value when one coat has exactly one pocket and another coat has multiple pockets, and no other coat has pockets. It seems to me that this meaning is overly specific. Since it is not my main purpose here to fully evaluate this analysis, I will leave not dwell on this point any further.

out that the idea of scalar implicatures of discourse referents allows us to dispense with such additional mechanisms, while keeping the analysis of partial plurality inferences.

2.2 The scalar implicature approach

The core assumptions of the scalar implicature approach to plurality inference are (i) that plural nouns are semantically number-neutral, and (ii) that a plurality inference arises from a plural noun as a scalar implicature via competition with its singular counterpart. (i) leads to a straightforward account of the number-neutral interpretation of plural nouns in negative contexts, while (ii) is meant to account for occurrences in positive contexts like (2a), repeated here as (6a). More specifically, the plurality inference of this example is generated in reference to its alternative in (6b), which has a singular noun in place of the plural noun.

(6) a. This coat has pockets.
    b. This coat has a pocket.

There is an issue here, however. Given the assumption that the plural noun is semantically number-neutral, these two sentences come out truth-conditionally equivalent. Specifically, it is clear that whenever (6a) is true, (6b) will be true. Furthermore, whenever (6b) is true, there must be at least one pocket on the coat, and this one pocket will be enough to make (6a) true, since the plural noun is semantically number-neutral. This truth-conditional equivalence of the two sentences is an issue for the scalar implicature approach, because in order to generate a scalar implicature, there needs to be some semantic asymmetry between the two sentences.

Different solutions to this issue can be found in the literature. Spector (2007) puts forward the idea of *higher-order implicatures*. Putting details aside, Spector's idea applied to (6a) amounts to that its crucial alternative is not (6b) on its literal reading, but this sentence with its own scalar implicature. Note that (6b) can have a reading that implies that the coat in question has only one pocket. Since this alternative is truth-conditionally more informative than (6a), (6a) will have a scalar implicature that the alternative is false, which, together with the literal meaning of (6a), implies that the coat has multiple pockets.

Ivlieva (2013, 2014, 2020), Mayr (2015), and Zweig (2009) pursue a different solution that resorts to *embedded implicatures*. Their crucial observation is that while the two sentences in (6) are truth-conditionally equivalent, the words and phrases that make them up are not, and one can find sub-constitutes of these sentences that have different truth-conditional meanings. Assuming that scalar implicatures can be drawn at the level of such sub-constituents, the plurality inference of (6a) can be computed as an embedded implicature. The authors cited here make use of different constituents, but these details are not very important for my purposes here.

At this point, let me briefly show that the scalar implicature approach can deal with both types of partial plurality inferences, unlike the ambiguity approach and the homogeneity approach. It turns out that no previous embedded implicature analysis offers a complete explanation of (2a), as pointed out by Ivlieva (2013, 2014), so I will assume Spector's (2007) higher-order implicature analysis here.[8]

Firstly, to derive the partial plurality inference for (4), observe first that the number-neutral semantics of the plural noun already correctly captures the negative part of its meaning. Then all we need is a scalar implicature that will imply that the unique coat that has one or more

[8] Ivlieva (2014) propposes a solution but it has two very stipulative aspects, which are yet to be given independent motivation. Firstly, it is assumed that when embedded, the operator that computes scalar implicatures, Exh, only affects the alternatives but not the prejacent, and alternatives need to be pruned under certain very specific circumstances.

pockets has multiple pockets. The crucial alternative is again the version of the same sentence with a singular noun in place of the plural noun. Spector (2007) assumes that this alternative can have a scalar implicature, which makes it synonymous with (7). I will not discuss here how this scalar implicature for this alternative is derived, as my analysis of the example under discussion will be much simpler and will not require higher-order implicatures.

(7) Exactly one of the coats has one or more pockets, and it is false that exactly one of the costs has multiple pockets.
= Exactly one of the coats has a pocket and it has only one pocket.

Since the literal meaning of (4) is truth-conditionally equivalent to the first part of (7), (7) is truth-conditionally more informative than (4). As a result, (4) will have a scalar implicature that (7) is false. Conjoining this scalar implicature with the literal meaning of (4), we obtain the overall meaning for this sentence that implies that the unique coat that has a pocket has multiple pockets.

Similarly, the partial plurality inference of (5) can be accounted for as follows. This is a case of scalar inferences in the domain of presuppositions and strictly speaking is not to be accounted for as a scalar implicature, but the core insight of the scalar implicature approach carries over to this case straightforwardly. That is, the scalar inference arises due to the singular alternative. More specifically, the number-neutral semantics of the plural noun *suitcases* predicts that (5) presupposes that every passenger has at least one suitcase, as presuppositions generally project universally through a universal quantifier (see, e.g. Heim 1983, Chemla 2009, Sudo 2012, 2014; but see Beaver 2001, Beaver & Krahmer 2001, George 2008, Fox 2012). Now, compare this example to the version of the sentence with the singular noun *suitcase* in place of the plural noun, (8).

(8) Every passenger lost their suitcase.

This sentence presupposes that every passenger has exactly one suitcase, which comes from the uniqueness presupposition of the definite singular noun together with presupposition projection through the universal quantifier. Now we assume that a scalar inference can be drawn in the domain of presupposition as well by a mechanism similar to how scalar implicatures are computed, as suggested in the literature (Heim 1991, Percus 2006, Sauerland 2008, Gajewski & Sharvit 2012, Spector & Sudo 2017, Marty 2017, Anvari 2019). Then, since the presupposition of (8) is stronger than the presupposition of (5) (while their at-issue meanings are equivalent), the latter comes to have the scalar inference that the presupposition of (8) is not met. This captures the fact that (5) is infelicitous when every passenger has exactly one suitcase.[9]

In sum, the scalar implicature approach, especially Spector's (2007) version, is the only approach in the current literature that can deal with both types of partial plurality inference, but previous implementations of it crucially rely on an additional mechanism, namely, either higher-order implicatures or embedded implicatures. I do not think these mechanisms are unfounded or empirically problematic. In fact, embedded implicatures have been given various empirical support (see, e.g. Chierchia et al. 2012), although empirical controversies persist in the experimental literature (Geurts & Pouscoulous 2009, Clifton & Dube 2010, Chemla & Spector 2011, Geurts & Van Tiel 2013, Cummins 2014, Van Tiel 2014, Potts, Lassitert, Levy & Frank 2016,

[9]Note that the resulting inference is weaker than the presupposition that at least one passenger has multiple suitcases, because it only anti-presupposes the presupposition of (8), i.e. the derived inference is that the presupposition of (8) is not satisfied in the current context, rather than that it is presupposed in the current context that the presupposition of (8) is false. See Chemla (2008) for an idea that an anti-presupposition can be pragmatically strengthened.

Franke, Schlotterbeck & Augurzky 2017, Van Tiel, Noveck & Kissine 2018). Also, the idea of higher-order implicatures seems to me to be conceptually very natural, especially if scalar implicatures are to be understood as pragmatic inferences in the classical Gricean sense. However, I will argue below that, as far as the plurality inference of plural nouns is concerned, there is no need for such additional mechanisms to begin with, given the consensus that discourse referents need to be postulated to account for pronominal anaphora.[10]

Before moving on, I would like to quickly remark on a potential objection that the reader might have about the scalar implicature approach to the plurality inference of plural nouns, namely that the inference feels much more robust than typical scalar implicatures. In particular, it does not seem to be possible to explicitly cancel a plurality inference, as illustrated by (9).

(9) This coat has pockets. ??In fact, it has only one.

In comparison, it is often considered that something like (10) is more or less acceptable, if not impeccable.

(10) She solved some of the problems. ?In fact, she solved them all.

Admittedly, the robustness of the plurality inference needs to be explained one way or another, but it's too hasty to conclude from this observation alone that the plurality inference is not a scalar implicature. Recent experimental research on scalar implicature reveals that different scalar items have scalar implicatures to different degrees of robustness (e.g., Van Tiel, van Miltenburg, Zevakhina & Geurts 2016, Van Tiel, Pankratz & Sun 2019, Meyer & Feiman 2020, Marty, Romoli, Sudo & Breheny 2020; see also Singh 2019, Bar-Lev & Fox 2020 for theoretical discussion). I do not have anything insightful to say about this poorly understood issue of diversity across scalar items in the present paper, but it is theoretically possible that the plurality inference is a very robust type of scalar implicature.[11] I would also like to reiterate that the scalar implicature approach to the plurality inference currently enjoys empirical superiority over its alternatives, especially with respect to partial plurality inferences. Furthermore, there is evidence from acquisition studies as well Pearson et al. (2010) and Tieu et al. (to appear) (see Tieu & Romoli 2019 for an overview).

[10]However, we will see cases involving quantifiers that are ambiguous and I will suggest that this ambiguity can be understood in terms of plurality inferences computed above vs. below the quantifier. This requires me to assume that embedded implicatures exist. However, the empirical controversies notwithstanding, it seems to be generally acknowledged that similar ambiguities are generally observed for scalar items occurring under quantifiers, and the current debate in the literature concerns how the embedded reading is to be accounted for. I will not delve into this debate in this paper.

[11]There is some experimental data that could be taken as suggesting that the plurality inference is not as robust as plain entailments. For instance, Anand, Andrews, Farkas & Wagers (2011) report an experiment (Experiment 4) where they tested the acceptability of sentences like (i) in contexts where there is only one entity that can be described by the plural noun (*teddy bears* here).

(i) The baby wearing yellow is playing with teddy bears.

In their results, the sentences were accepted 17% of the time (as opposed to 98% when there are more than one entity describable by the plural noun). Similarly, Tieu, Bill, Romoli & Crain (to appear) tested similar sentences in their acquisition studies. The adult participants of of their Experiment 2 accepted it 25% of the time, which was comparable to the scalar implicature triggered by *some*, although in their Experiment 1, similar sentences were only accepted 8% of the time by their adult participants.

2.3 A rough sketch of the proposal

The version of the scalar implicature approach to the plurality inference I put forward below makes crucial use of discourse referents. I will illustrate the analysis with the same examples as above. In (11), discourse referents are explicitly marked.[12]

(11) a. This coat has [pockets]^x. (But they$_x$ are not very big.)
b. This coat has [a pocket]^x. (But it$_x$ is not very big.)

Since these sentences do feed pronominal anaphora, as indicated in parentheses, there is evidence for the discourse referents.[13] I follow the previous proponents of the scalar implicature approach and assume that a singular noun is only true of atomic entities, while a plural noun is semantically number-neutral. Recall that this assumption renders the above two sentences truth-conditionally equivalent, which was an issue for the scalar implicature approach, because in order to generate a scalar implicature there needs to be some semantic asymmetry between them.

My version the scalar implicature approach distinguishes itself from its predecessors in that it finds the crucial semantic asymmetry in the discourse referents of the sentences, rather than in their truth-conditions. That is, given the above assumptions about the nouns, the discourse referent introduced in (11a) is not specified for number, so x can refer to an atomic pocket or a plurality of pockets, while the discourse referent introduced in (11b) is specified to be singular, referring to an atomic pocket. Since the latter discourse referent is more informative in the sense that it has more precise information about what it represents, a scalar implicature is drawn for the former that whatever the latter means is not the case. This ultimately amounts to restricting the possible referents of x in (11a) to non-atomic entities, which is the plurality inference.

This is roughly the idea of my analysis. I skipped many details, including important questions about how exactly to define informativity for discourse referents and how to actually draw a scalar implicature. I will make these points formally more precise below by implementing this analysis in dynamic semantics, and then I will show how the resulting theory accounts for the interaction with quantifiers, including cases of partial plurality inferences. As we will see, the explanation for (5) will be essentially identical to what we reviewed above, but the analysis of (4) under the present account is worth characteristing in informal terms here. Specifically, the relevant two sentences are as follows. The crucial observation here is that they do introduce discourse referents about pockets, as evidenced by the continuations in parentheses here.

(12) a. Exactly one of these coats has pockets^x. (They$_x$ are outside.)
b. Exactly one of these coats has [a pocket]^x. (It$_x$ is outside.)

Here again, we reason about what x can be. Given the semantic assumptions about nominal number, x in (12a) can be an atomic pocket or a plurality of pockets. On the other hand, x in (12b) is restricted to be an atomic pocket. Then by the same reasoning as above, we derive the

[12] Here and throughout, I will use the Barwise notation where a newly introduced discourse referent is represented as a superscript, and reference to an old discourse referent is represented as a subscript. I will also assume without argument that discourse referents are introduced by noun phrases, but what is crucial here is not where discourse referents are introduced in the compositional semantics, but the anaphoric properties at the sentential level (or more precisely, at the level where the plurality inference is computed). Needless to say, sub-sentential compositionality is obviously an important and interesting question, but I will not address it in this paper.

[13] Note that the pronouns differ in number, but this is as we expect, because (11a) has a plurality inference after all and by the time the pronoun is processed, x is already understood as referring to a plurality. On the other hand, for (11b), x is supposed to be a single pocket, so the pronoun should be singular. We will see how my account of the plurality inference gives rise to these results in detail the next section.

inference for (12a) that x must refer to a plurality of pockets. Thus, the derivation is completely parallel to the non-quantified example in (11a).

3 Dynamic semantics primer

I will now introduce a simple dynamic semantic system, in order to formalise the proposal I have just sketched in informal terms. I will augment it with generalised quantifiers in Section 5, but the core part of the system will stay the same. I would like to emphasise that my choice of the framework here is not theoretically crucial, and I could have chosen an alternative way to formally represent discourse referents. However, to the best of my knowledge, dynamic semantics is the only framework that is fully worked out in certain crucial respects. To make this point clearer, let me start with some additional discussion on the idea of discourse referents.

3.1 Discourse referents

Dynamic semantics represents discourse referents as variables, as we will see more concretely below, but the idea of discourse referents as carriers of anaphoric information is conceptually not married to this particular implementation, and in principle, my analysis of plurality inference sketched above could be implemented in alternative ways of representing discourse referents.

For example, the so-called *E-type* approach couched in situation semantics (Heim 1990, Elbourne 2005) is often contrasted with dynamic semantics. It would account for the contrast in (1), repeated here, roughly as follows.

(1) a. Paul has a TIN. But he hasn't used it in a while.
b. Paul is a registered taxpayer. ??But he hasn't used it in a while.

The truth-conditions of the first sentences of these examples are contextually equivalent but they differ in two crucial respects: (i) what kind of situations they mention, and (ii) what kind of noun phrases they make salient. By assumption, a successful use of *it* in the second sentence to refer to Paul's TIN requires a prior mention of a situation that contains a unique TIN, and also the noun *TIN* to be salient in the discourse. Both of these are satisfied in (1a) but not satisfied in (1b). In this framework, we can regard 'discourse referents' as carriers of these two pieces of information.

It should be remarked here that the debate about the E-type vs. dynamic approach to pronominal anaphora is often phrased in terms of static vs. dynamic semantics, but as far as discourse anaphora like (1) is concerned, there is no way that the E-type system can stay completely static. In other words, the debate is only about whether the meanings of quantificational determiners and certain connectives involved in donkey anaphora need to be inherently dynamic or can stay static, and when it comes to discourse anaphora, any approach requires some dynamic mechanism that passes information from one sentence to another.[14] However, the relevant dynamic aspect of the E-type approach is often not formalised (but see Mandelkern & Rothschild 2019), so I will not use this theory in this paper.

Another approach to pronominal anaphora is suggested by Stalnaker (1989:11), which is an attempt to stay as conservative as possible with respect to how to model discourse contexts, by accounting for pronominal anaphora solely in terms of a set of possible worlds. The crucial observation is that while the truth-conditions of the first sentences of (1) are indeed contextually

[14]The debate also tends to ignores anaphora across conjuncts, which needs a certain degree of dynamicization even within a single sentence. See Mandelkern & Rothschild (2019) for detailed discussion.

equivalent, their assertions do not result in the exact same common ground. That is, after the utterance of the first sentences, the common ground will be slightly different between the two cases, because in the first case, it will be commonly known that the speaker has uttered the first sentence of (1a), while in the second case, it will be commonly known that the speaker has uttered the first sentence of (1b). Stalnaker conjectures that this difference makes a difference with respect to pronominal anaphora. Under this view, therefore, we could think of discourse referents as such differences in the set of possible possible. However, it has not been fully specified exactly how such information is used in resolving pronominal anaphora.

Therefore, practically speaking, the only framework of pronominal anaphora that is formally worked out precisely enough to be useful for my purposes in this paper is dynamic semantics.

3.2 A primer for dynamic semantics

In dynamic semantics, sentence meanings are modelled as functions over *information states*, which are formal representations of (certain relevant aspects of) discourse contexts. Following Heim (1982), we take information states to be sets of world-assignment pairs. Each world-assignment pair is meant to represent a live possibility according to the common ground among the interlocutors at a given point in discourse, so let us call world-assignment pairs *possibilities*. It will be convenient to be able to refer to just the worlds or just the assignments found in a given information state, so we will use the following functions that bisect the possibilities and discard one of the components.

(13) For any information state c,

a. $\mathsf{W}(c) = \{\, w \mid \langle w, a\rangle \in c \text{ for some } a \,\}$

b. $\mathsf{A}(c) = \{\, a \mid \langle w, a\rangle \in c \text{ for some } w \,\}$

Note that there are versions of dynamic semantics that are simpler than this, e.g. Groenendijk & Stokhof's (1991) Dynamic Predicate Logic (DPL), where an information states is a single pair of world-assignment, or even just a single assignment with out a world, rather than sets thereof. As we will see, it will be useful to explicitly represent sets of world-assignment pairs for the present purposes, and when we discuss presuppositions, this will be crucial, so we will stick to this setup.[15]

The rest of this subsection will introduce the formal details of the dynamic semantic system I will be using. I believe it is standard, including the notation, so if the reader is familiar with dynamic semantics, they can safely skip to the next subsection.

Recall now that a sentence in natural language has truth-conditions as well as a separate type of meaning related to pronominal anaphora. In the current version of dynamic semantics, this can be thought of as follows: A sentence's truth-conditional meaning operates on the worlds in $\mathsf{W}(c)$ of an information state c and its anaphoric meaning operates on the assignments in $\mathsf{A}(c)$. For example, a simple sentence with no quantifiers or connectives have trivial anaphoric meaning and do not change $\mathsf{A}(c)$, but still operates on $\mathsf{W}(c)$, as illustrated in (14). I will use the post-fix notation where $c[\phi]$ is the result of applying ϕ's denotation to information state c, which is a formal representation of an assertion of ϕ made the discourse context that c represents. We call an application of a sentence denotation to an information state an *update*, and read $c[\phi]$ as 'c updated with ϕ'.

[15] To put it conversely, the analysis of scalar implicatures *per se* could be reformulated in a point-wise version of dynamic semantics, like DPL, because the core system is entirely distributive (in the sense of Rothschild & Yalcin 2016), and the only non-distributive part of the system is presuppositions. I will not offer such an alternative version of the theory in this paper, but the necessary formal translation should be more or less routine.

(14) a. c[`It is raining in London`] $= \{ \langle w, a \rangle \in c \mid$ it is raining in London in $w \}$

b. c[`Paul is a registered taxpayer`]
$= \{ \langle w, a \rangle \in c \mid$ Paul is a registered taxpayer in $w \}$

As these representations make clear, the sentences only put constraints on what w can remain in the resulting information state.[16] Note, however, that these updates might have indirect consequences on the assignments. For instance, one can take an information state c where some assignments in $\mathsf{A}(c)$ map x to Nathan, but all such assignments are paired with worlds where it is sunny in London. Then as a result of the update in (14a), we will lose all assignments that map x to Nathan.

In this paper we will not be concerned with sub-sentential compositional semantics. One can of course build a compositional semantic analysis of sentences like (14), and it would ultimately be of interest for my analysis of the plurality inference, but this is beyond the scope of this single paper. See Groenendijk & Stokhof (1990), Muskens (1996), Brasoveanu (2007), Charlow (2014), among others, for relevant discussion.

Assignments are used to enable pronominal anaphora. We assume that pronouns are interpreted as discourse referents, which are modelled as variables, as illustrated below. We will ignore presuppositions in this section, so I will not explicitly represent the information coming from the ϕ-features of these pronouns.

(15) a. c[`Nathan emailed him`$_y$] $= \{ \langle w, a \rangle \in c \mid$ Nathan emailed $a(y)$ in $w \}$

b. c[`He`$_y$ `doesn't remember it`$_x$] $= \{ \langle w, a \rangle \in c \mid a(y)$ doesn't remember x in $w \}$

Pronominal anaphora only succeeds if the discourse referent in question has already been introduced in the discourse context. In other words, an information state specifies which discourse referents has been introduced so far. There are several different formal ways of representing this information (see, e.g., Heim 1982, Van Eijck 2001, Nouwen 2007), but the following simple idea will do for the purposes of the present paper. Assignments are partial functions from variables to entities, and pronominal anaphora with respect to discourse referent x fails in c when any assignment of $\mathsf{A}(c)$ is undefined for x.

Discourse referents can be introduced in several distinct ways (Heim 1982), but the only relevant one for now is via indefinites, as illustrated by (16).

(16) c[`Paul has [a TIN]`^{x}]
$= \{ \langle w, a[x \mapsto n] \rangle \mid \langle w, a \rangle \in c$ and n is Paul's TIN in $w \}$

$a[x \mapsto n]$ is an assignment that is different from a at most in that $x \in \mathrm{dom}(a[x \mapsto n])$ and $a[x \mapsto n](x) = n$. Suppose that that $\mathsf{A}(c)$ contains assignments that are not defined for x. Even if that is the case, the output of the update in (16) yields a context where all assignments are defined for x. Contrast this with (14b), which does not introduce a discourse referent x. There, the result of the update will still contain assignments undefined for x (as long as these assignments are paired with worlds where Paul is a registered taxpayer). This accounts for the contrast we started out with.

It is convenient to assume that an indefinite is always associated with a new variable with respect to the input information state c, i.e. for each $a \in \mathsf{A}(c)$, $x \notin \mathrm{dom}(a)$, because this prevents information loss. This condition is often called the *Novelty Condition* (cf. Heim 1982), and I

[16] Note that we are ignoring Stalnaker's (1989) reasonable idea that an assertion of ϕ will make it commonly known that ϕ has been just uttered. We could include this bit of information, but it would make no difference with respect to my analysis of plurality inference, so I will ignore it in this paper.

assume it to be a presupposition.[17]

For the sake of completeness, we will also introduce some connectives. The negation is interpreted as (17a), which makes reference to the idea of *extension*: Assignment a' is an extension of assignment a, $a \preceq a'$, iff for each $x \in \text{dom}(a)$, $x \in \text{dom}(a')$ and $a(x) = a'(x)$. Note that every assignment is an extension of itself.

(17) a. $c[\texttt{not}\ \phi] = \{\, \langle w, a \rangle \in c \mid \text{there is no } a' \text{ such that } a \preceq a' \text{ and } \langle w, a' \rangle \in c[\phi] \,\}$
 b. $c[\phi\ \texttt{and}\ \psi] = c[\phi][\psi]$

We will not discuss disjunction and conditionals in this paper, as they are highly controversial in the semantic literature. A proper dynamic treatment of disjunction turns out to be elusive, especially with respect to pronominal anaphora (see, for example, Stone 1992, Rothschild 2017), and it seems to me that there is no concrete enough dynamic analysis of disjunction that is empirically satisfactory. To make the matter worse, disjunction introduces its own scalar implicature, and generally speaking, sentences containing multiple scalar items involve complications that pose additional theoretical challenges (see, e.g., Chierchia 2004, Fox 2007, Romoli 2012, Franke & Bergen 2020, Bar-Lev & Fox 2020 for relevant discussion).

Similarly, conditionals are outside the scope this paper. The dynamic semantic literature often contains a material implication analysis, but it is known to be inadequate for conditionals in natural language. Rather, it is considered that a proper analysis of conditionals requires intensional semantics one way or another. In addition to the heated debate over which intensional theory of conditionals is more appropriate (see von Fintel 2011, 2012, Kaufmann & Kaufmann 2015, Égré & Cozic 2016 for recent overviews), intensionality will bring in further complications that have to do with *de re* reference, which I cannot deal with in this single paper.

Instead of these additional connectives, I will explore the predictions of the theory with respect to extensional quantificational contexts in Section 5.

3.3 Adding plurality

Finally, we need to augment the above simple dynamic semantic theory with plurality, as the main empirical interest of this paper is the plurality inference. Following the standard tradition on plurality (Link 1983, Schwarzschild 1996, Landman 2000, Winter 2000 among others), we will postulate plural entities, in addition to atomic entities, in our semantic model. From the domain D of a given model, which is the set of atomic entities, we define the domain of entities D_e as the closure of D with the plurality forming operator, $\oplus$. By assumption, $\oplus$ is commutative, associative, and idempotent, so $\langle D_e, \oplus \rangle$ is a semi-lattice. $\oplus$ induces a part-whole relation $\sqsubseteq$ in the usual manner: For any $x, y \in D_e$, $x \sqsubseteq y$ iff $x \oplus y = y$, and $x \sqsubset y$ iff $x \sqsubseteq y$ and $x \neq y$. Atomic entities have no proper parts, i.e. for $x \in D$, there is no y such that $y \sqsubset x$.

Now we allow discourse referents to refer to plural entities in addition to atomic entities. Recall we assume that a plural noun is semantically number-neutral, while a singular noun is semantically singular. This is represented as in (18), where I is the interpretation function of the model.

(18) a. $x \in I_w(\texttt{pocket})$ iff $x \in D$ and x is a pocket in w
 b. $x \in I_w(\texttt{pockets})$ iff each atomic part of x is a pocket in w

[17] One could alternatively derive it in terms of an anti-presupposition in reference to the definite version of the sentence, as suggested by Heim (1991). I believe this will eventually be better, but it would introduce unnecessary complications that are orthogonal to my main goal in this paper.

Note that (18b) is number-neutral, because when x is an atomic entity, then there is only one atomic part of it, namely, x itself. The universal quantification over atomic parts here can be understood as reflecting the inherent distributivity of the plural noun. In this paper, we will not discuss non-distributive predication, but the semantic theory assumed here can be extended to accommodate it (cf. Van den Berg 1996, Brasoveanu 2007, 2008).

Since we do not deal with sub-sentential compositionality in the present paper, the analysis of nouns themselves is not very important, but what is crucial is that sentences containing these nouns give rise to different meanings. Let us consider (19). To simplify the discussion let us assume that *this coat* denotes an atomic coat k in every world in $\mathsf{W}(c)$.

(19) a. $c[\texttt{This coat has [a pocket]}^x]$

$$= \left\{ \langle w, a[x \mapsto e] \rangle \;\middle|\; \begin{array}{l} \langle w, a \rangle \in c \text{ and } k \text{ has at least one pocket in } w \\ \text{and } e \text{ is an atomic pocket of } k \text{ in } w \end{array} \right\}$$

b. $c[\texttt{This coat has pockets}^x]$

$$= \left\{ \langle w, a[x \mapsto e] \rangle \;\middle|\; \begin{array}{l} \langle w, a \rangle \in c \text{ and } k \text{ has at least one pocket in } w \\ \text{and each part of } e \text{ is a pocket of } k \text{ in } w \end{array} \right\}$$

It is important to understand how exactly the resulting contexts differ, so let us consider a concrete example information state. Let us assume that c is an information state that is ignorant about whether or not k has pockets and is open to the possibility that it has exactly one pocket as well as to the possibility that it has two (but not to the possibility that it has more than two). To stay as simple as possible, let us assume that $\mathsf{W}(c) = \{ w_0, w_1, w_2 \}$, where k has no pockets in w_0 and exactly one pocket p in w_1 and exactly two pockets p_L and p_R in w_2. Assignments in c could be anything, but just to have some variation, let us suppose:

$$c = \left\{ \begin{array}{l} \langle w_0, a \rangle, \langle w_0, b \rangle, \langle w_0, d \rangle, \\ \langle w_1, a \rangle, \langle w_1, c \rangle, \\ \langle w_2, b \rangle, \langle w_2, c \rangle \end{array} \right\}.$$

There can well be more worlds and more assignments, but I do not want to clutter the exposition too much, so I will work with this toy example. Updating this information state with the above two sentences, we will get the following information states, which I will call c'_s and c'_p respectively.

(20) a. $c[\texttt{This coat has [a pocket]}^x]$

$$= \left\{ \begin{array}{l} \langle w_1, a[x \mapsto p] \rangle, \langle w_1, c[x \mapsto p] \rangle, \\ \langle w_2, b[x \mapsto p_L] \rangle, \langle w_2, b[x \mapsto p_R] \rangle, \\ \langle w_2, c[x \mapsto p_L] \rangle, \langle w_2, c[x \mapsto p_R] \rangle \end{array} \right\} = c'_s$$

b. $c[\texttt{This coat has pockets}^x]$

$$= \left\{ \begin{array}{l} \langle w_1, a[x \mapsto p] \rangle, \langle w_1, c[x \mapsto p] \rangle, \\ \langle w_2, b[x \mapsto p_L] \rangle, \langle w_2, b[x \mapsto p_R] \rangle, \langle w_2, b[x \mapsto p_L \oplus p_R] \rangle, \\ \langle w_2, c[x \mapsto p_L] \rangle, \langle w_2, c[x \mapsto p_R] \rangle, \langle w_2, c[x \mapsto p_L \oplus p_R] \rangle \end{array} \right\} = c'_p$$

Several remarks are in order. First, neither $\mathsf{W}(c'_s)$ nor $\mathsf{W}(c'_p)$ contains w_0. This is because the truth-conditional meanings of these sentences eliminate any possibility whose world is w_0. Second, notice that $\mathsf{W}(c'_s) = \mathsf{W}(c'_p) = \{ w_1, w_2 \}$. This reflects the observation mentioned in Section 2.2 that pairs of sentences like these are truth-conditionally identical, on the assumption that plural nouns are number-neutral. Third, c'_s and c'_p are nonetheless distinct sets, and their crucial difference comes from the fact that $\mathsf{A}(c'_s) \neq \mathsf{A}(c'_p)$. In particular, each assignment in $\mathsf{A}(c'_s)$ assigns an atomic pocket to x, and while the same assignments can also be found in $\mathsf{A}(c_p)$, $\mathsf{A}(c_p)$ contains additional ones that assign a plurality of pockets $p_L \oplus p_R$ to x. Thus, we have $\mathsf{A}(c'_s) \subset \mathsf{A}(c'_p)$. This is exactly the semantic asymmetry that we will make use of to derive the plurality inference as a scalar implicature. We will discuss this in detail in the next section.

3.4 Excursus: non-maximality

Note that what is represented above is non-maximal readings of the indefinites in the sense that x is not required to denote a maximal entity with respect to $\sqsubseteq$ in the respective possible worlds that complies with the number marking. More specifically, the maximal reading of the singular indefinite would amount to that k has exactly one pocket, which would rule out possibilities whose world component is w_2. Since *a*-indefinites generally allow for non-maximal readings, the above analysis is fine at least as a possible reading of the sentence. One might also want to derive the maximal reading as a separate reading, which could be achieved by postulating lexical ambiguity *a*-indefinites (see Brasoveanu 2007, 2008), or by deriving it as a scalar implicature (see Spector 2007). This aspect of the semantics of *a*-indefinites is not crucial for my main goal here, so I will leave it open here.

The non-maximality of the plural example is potentially more problematic. This is not obvious in the above example, as there is only one relevant plurality, and the atomic referents will be eventually eliminated due to the plurality inference. However, suppose that the input information state c contains a world w_3 where k has three pockets, p_1, p_2 and p_3. Let us suppose that $\langle w_3, d\rangle \in c$. Then after the update with the plural sentence, the information state c'_p will contain each of the following seven extensions of d.

$$\begin{array}{lll} d'_1(x) = p_1 & d'_2(x) = p_2 & d'_3(x) = p_3 \\ d'_4(x) = p_1 \oplus p_2 & d'_5(x) = p_2 \oplus p_3 & d'_6(x) = p_1 \oplus p_3 \\ d'_7(x) = p_1 \oplus p_2 \oplus p_3 & & \end{array}$$

d'_1, d'_2 and d'_3 will eventually be removed by the plurality inference, but we will still have three assignments, d'_4, d'_5, and d'_6 that assign a non-maximal plurality to x, in addition to d'_7, which assigns the maximal entity $p_1 \oplus p_2 \oplus p_3$ in w_3.

It is often remarked in the literature (e.g. Brasoveanu 2007, 2008) that plural indefinites only allow for maximal readings, based on examples like the following.

(21) This coat has [pockets]^x. They$_x$ are inside.

That is, the second sentence here seems to mean that all the pockets of the coat are inside, rather than at least two of them are inside. This maximality effect is not accounted for by the above semantics. One way to fix it without changing our analysis of plural nouns is to assume that the plural pronoun triggers a maximality effect. That is, it discards all non-maximal values, as in (22).

(22) $c[\texttt{They}_x\ \texttt{are inside}]$

$$= \left\{ \langle w, a\rangle \in c \;\middle|\; \begin{array}{l} \text{each atomic part of } a(x) \text{ is inside in } w \text{ and} \\ \text{for no } \langle w, a'\rangle \in c,\ a(x) \sqsubset a'(x) \end{array} \right\}$$

It is of course a legitimate question why plural pronouns behave like this. However, I would like to point out that it seems to me that singular pronouns also trigger this effect (cf. Evans 1980, Heim 1982). Consider (23).

(23) This coat has [a pocket]^x. It$_x$ is inside.

It seems to me that this strongly implies that the coat has only one pocket, which is a maximality effect on a par with (22). If this is correct, the semantics of a-indefinites we gave above will not account for it by itself. We can fix it by giving a parallel maximal account of the singular pronounce as in (24).

(24) $$c[\texttt{It}_x \texttt{ is inside}] = \left\{ \langle w, a \rangle \in c \;\middle|\; \begin{array}{l} a(x) \text{ is inside in } w \text{ and} \\ \text{for no } \langle w, a' \rangle \in c,\, a(x) \neq a'(x) \end{array} \right\}$$

Having said that it is true that a singular pronounce with an a-indefinite antecedent sometimes does not seem to have maximality effects. For instance, (25) does not imply that there is only one supermarket near my flat.

(25) There is [a supermarket]^x near my flat. It$_x$ is open until midnight.

However, it's not very clear if this is a problem, because the maximal pronoun in (24) can be made compatible with this observation, on the assumption that domain restriction is possible in the first sentence. Rather, the real question is whether singular and plural pronouns and indefinites behave differently. In fact, I am not sure if the plural version of this sentence differs from (25) in this respect. That is, (26) does not seem to imply that all the supermarkets near my flat are open until midnight.

(26) There are [supermarkets]^x near my flat. They$_x$ are open until midnight.

I refrain from making strong empirical claims here about these examples, but as far as I can see, pronouns can be blamed for maximality effects, as suggested above,[18] and if so, we do not have to make changes to our analysis of singular and plural indefinites.

4 Scalar implicatures with discourse referents

We are now ready to derive the plurality inference. According to our analysis of singular and plural indefinites given in (19), they give rise to the same truth-conditional effects but different anaphoric potentials. Continuing to call the resulting information states of these examples c'_s and c'_p, this means that $\mathsf{W}(c'_s) = \mathsf{W}(c'_p)$, and also whenever there is a world in $\mathsf{W}(c)$ where the coat k has more than one pocket, we are bound to have $\mathsf{A}(c'_s) \subset \mathsf{A}(c'_p)$.[19] This means that there is a semantic asymmetry between the two sentences such that the singular version of the sentence

[18] Note also that this is not particularly surprising, if pronouns and definite descriptions share certain core semantic components, as suggested by their semantic as well as morphosyntactic similarities found across languages (see Postal 1966, Elbourne 2005, among many others), although this is not directly reflected in the version of dynamic semantics assumed here. Ultimately, one might want to pursue a dynamic account that somehow incorporates insights from the analysis of pronouns as disguised definite descriptions.

[19] Conversely, if there is no such world in $\mathsf{W}(c)$, then the two sentences will be contextually equivalent. Notice that in that case, the plural version is actually infelicitous. Under the scalar implicature approach to the plurality inference, this can be understood as a special case of a general phenomenon that applies to all scalar implicatures in general. Magri (2009a,b) discusses this in depth, and argues that it gives strong support for the grammatical approach to scalar implicature (see also Fox & Hackl 2006). Specifically, he proposes that when the crucial alternative is contextually equivalent, then the scalar implicature that it gives rise to becomes obligatory, and argues that since this requires the computation of scalar implicature itself to be blind to contextual information, it is incompatible with the pragmatic approach. As discussed below, the present account of the plurality inference can be implemented in the grammatical approach, so we can follow Magri to account for the above observation along the lines that he suggests.

is more informative, and we can capitalise on this to draw a scalar implicature. I will present two different ways of deriving a scalar implicature, one pragmatic and one grammatical, as the literature is split between these two camps.

4.1 Informativity in dynamic semantics

Let us first be more precise about the notion of informativity. As I remarked in the introduction, most of the literature on scalar implicature exclusively focusses on informativity with respect to truth-conditions. That is, ϕ is more informative (alt. stronger) than ψ iff whenever ϕ is true, ψ is true but not vice versa. Let us call this notion of informativity *truth-conditional informativity*. In the version of dynamic semantics we are using, it can be formalised as follows.

(27) ϕ is *truth-conditionally more informative* than ψ iff for each information state c, $\mathsf{W}(c[\phi]) \subseteq \mathsf{W}(c[\psi])$, and there is at least one information state c' such that $\mathsf{W}(c'[\psi]) \nsubseteq \mathsf{W}(c'[\phi])$.

According to some theories of scalar implicature, the relevant notion of informativity is contextually localised, which can be defined as (28).

(28) ϕ is *contextually truth-conditionally more informative* than ψ with respect to information state c iff $\mathsf{W}(c[\phi]) \subset \mathsf{W}(c[\psi])$.

The difference between (27) and (28) is essentially the same as the difference between entailment *simpliciter* vs. contextual entailment, when entailment is understood truth-conditionally.

These notions of informativity are not useful for the phenomenon we are after, the plurality inference, because regardless of what the original information state c is, it is guaranteed that $\mathsf{W}(c'_s) = \mathsf{W}(c'_p)$. However, this is not the only notion of informativity, and the version of dynamic semantics lends itself to formally representing ones that have to do with anaphora. For instance, we can define notions that are just like (27) and (28) above but are about assignments, which I call *anaphoric informativity*.

(29) ϕ is *anaphorically more informative* than ψ iff for each information state c, $\mathsf{A}(c[\phi]) \subseteq \mathsf{A}(c[\psi])$, and there is at least one information state c' such that $\mathsf{A}(c'[\psi]) \nsubseteq \mathsf{A}(c'[\phi])$.

(30) ϕ is *contextually anaphorically more informative* than ψ with respect to information state c iff $\mathsf{A}(c[\phi]) \subset \mathsf{A}(c[\psi])$.

Furthermore, we can define a notation that refers to both aspects of meaning at the same time. Let's call this *dynamic informativity*.

(31) ϕ is *dynamically more informative* than ψ iff for each information state c, $c[\phi] \subseteq c[\psi]$, and there is at least one information state c' such that $c'[\psi] \nsubseteq c'[\phi]$.

(32) ϕ is *contextually dynamically more informative* than ψ with respect to information state c iff $c[\phi] \subset c[\psi]$.

4.2 Pragmatic implementation

At this point let us recall Grice's intuition: An utterance of sentence ϕ has a scalar implicature, when there is an alternative sentence ψ that could have been used to mean something more informative. The classical Gricean theory of scalar implicature explains this by making crucial use of *Maxim of Quantity*.

(33) Maxim of Quantity

a. Make your contribution as informative as is required.
b. Do not make your contribution more informative than is required.

Under this view, it's most natural to understand the relevant notion of informativity in terms of (32), since there is no reason to limit the comparison to one particular dimension of meaning, and also because pragmatic reasoning is specific to a particular discourse move in a particular context, so all one cares about should be contextually localised informativity. Let us see how the plurality inference can be drawn under this theory.

Upon hearing *This coat has pockets*^{x} with a plural indefinite, the hearer notices that the speaker could have uttered *This coat has [a pocket]*^{x} instead, which would have been contextually dynamically more informative.[20] Notice that the reason why the speaker didn't use this alternative cannot be because they don't believe it to be true, because we know that the two sentences are truth-conditionally equivalent. Rather, it must be because the speaker wants x to be able to denote a plural value.

At this point, the inference is simply that for at least one $\langle w, a\rangle \in c'_p$, $a(x)$ is a plurality. However, this is too weak for the plurality inference, which amounts to that for each $\langle w, a\rangle \in c'_p$, $a(x)$ is a plurality. As is well known, implicatures derived pragmatically by the Maxim of Quantity are generally weaker than scalar implicatures. For instance, take the sentences in (34). I will (tentatively) assume that these sentences introduce no discourse referents so we can zoom in on their truth-conditions (but see Section 5).

(34) a. Most of the windows are closed.
b. All of the windows are closed.

The predicted implicature of (34a) under the Gricean theory is that the speaker is not certain that (34b) is true, rather than that they are certain that it is false, because being uncertain about its truth is good enough reason for not asserting it, given the Maxim of Quality, according to which one should only assert what one believes is true.

Sauerland (2004) called such a weak implicature a *primary implicature*, and proposed that it can be strengthened to a stronger *secondary implicature* with an additional assumption that the speaker is opinionated about the alternative, i.e. either they are certain that it is true, or they are certain that it is false (see also Horn 1989, Spector 2006). Since the derived inference is incompatible with the alternative being true, it must be false, which is the scalar implicature.

In order to derive the plurality inference as a scalar implicature under the Gricean theory, therefore, we need a comparable extra assumption. But this cannot be about the speaker's opinionatedness about the truth and falsity of the alternative, because the inference is not about them. Rather, the necessary assumption is about the values of x, namely, that either the speaker intends x to denote an atomic entity in each possibility, or they want it to denote a plural entity in the resulting information state. This assumption, together with the implicature we derived with the Maxim of Quantity, will result in the plurality inference.

But why would one assume that the speaker intends a uniformly singular or uniformly plural discourse referent at all? While I concede that I won't be able to provide a completely satisfactory answer to this question, I would like to remark on two things. Firstly, unlike the opinionatedness assumption, which is about the speaker's epistemic state, what to encode in a discourse referent is completely up to the speaker. That is, the speaker has full control over whether or not to introduce a discourse referent and what to encode in a discourse referent, as

[20] Here, the previous footnote becomes relevant. For the sake of discussion, let us simply assume that the singular and plural versions of the sentence are not contextually equivalent.

they depend solely on what expressions the speaker uses.[21] Secondly, in a language like English, there are broadly two types of nouns, count and mass. Count nouns are generally used for discrete, countable objects and ideas, while mass nouns can be used to describe countable or uncountable objects (Barner & Snedeker 2005, Bale & Barner 2009, Chierchia 1998, 2010, Lima 2018, Link 1983, Rothstein 2017, among many others). Thus, perhaps by using a count noun, the speaker signals that countability is relevant, which makes the distinction between singular and plural entities salient. Given that this distinction is salient, the speaker is likely to deem it important, and perhaps it is justifiable that they want their discourse referent to not crosscut this distinction.

At this point, this extra assumption lacks independent evidence, but it does not seem to me to be particularly less plausible than the opinionnatedness assumption needed for other scalar implicatures under the Gricean analysis of scalar implicature. It should also be noted that there are other broadly pragmatics accounts of scalar implicatures such as Franke's (2011) Iterated Best Response model and Bergen, Levy & Goodman's (2016) Rational Speech Act model, which do not require such extra assumptions to derive scalar implicatures. It is not my purpose here to compare different theories of scalar implicature, but to show that the idea of scalar implicatures with discourse referents is a theoretically legitimate idea, so instead of delving into these different pragmatic theories of scalar implicature, I will sketch an implementation of the same idea in a completely different approach, namely, the grammatical approach. It will also help us see certain crucial aspects of the present analysis more explicitly.

4.3 Grammatical implementation

According to the grammatical approach to scalar implicature (Chierchia et al. 2012, among others), scalar implicatures are semantic entailments, rather than pragmatically derived inferences. The currently standard implementation of this idea postulates a phonologically null operator. Following Fox (2007) among others, I will call it *Exh* here, which is standardly defined as (35) in a static semantic framework.

(35) $[\![\text{Exh}(\phi)]\!]^{w} = [\![\phi]\!]^{w} = 1$ and for each excludable alternative ψ to ϕ, $[\![\psi]\!]^{w} = 0$.

Whether a scalar implicature arises depends on whether this operator is present in the structure, as well as on whether excludable alternatives exist. Several ways of characterising excludable alternatives have been discussed in the literature (see, e.g., Fox 2007, Spector 2016), but they all build on a general theory of alternatives that defines what counts an alternative to begin with, among which excludable ones are identified. Since it is currently an open issue to construct a general theory of alternatives (see Katzir 2007, Fox & Katzir 2011, for attempts; see also Breheny, Klinedinst, Romoli & Sudo 2018 for an overview of current open issues), I will not deal with this issue in this paper, but note that this is a common problem for all theories of scalar implicature, including the Gricean and other pragmatic theories. What is of more interest for us is that different ways of identifying excludable alternatives that are currently assumed in the literature are all based on truth-conditional informativeness. The simplest among them states that ψ is an excludable alternative to ϕ iff ψ is an alternative to ϕ and is truth-conditionally more informative than ϕ. Note that the relevant notation of informativeness is assumed to be blind to contextual information (Fox & Hackl 2006, Magri 2009a,b, Fox & Katzir 2020), so it is to be understood in terms of truth-conditional informativeness *simpliciter*, (27), rather than contextual truth-conditional informativeness, (28). I will not review arguments for the contextual

[21] One might be tempted to speculate that the robustness of the plurality inference mentioned at the end of Section 2.2 has to do this with. I leave this idea open here.

blindness of Exh here.

We know that truth-conditional informativity will not be useful for the plurality inference, so we have to use one of the other notions to define excludable alternatives. In order to do so we also have to make Exh sensitive to discourse referents by dynamicising it. The following analysis captures Grice's core intuition more or less straightforwardly.

(36) $c[\mathtt{Exh}(\phi)] = \bigcap_{\psi_i}(c[\phi] - c[\psi_i])$ for each excludable alternative ψ_i to ϕ

In most examples we will discuss, there is only one excludable alternative ψ, so the meaning with the scalar implicature will look like $c[\phi] - c[\psi]$, where $c[\phi]$ corresponds to the literal meaning under the Gricean pragmatic approach, and $c[\psi]$ corresponds to what the alternative would have meant had it been used instead in the same context. Note that this latter meaning is 'negated' in a particular way. That is, all the possibilities that would have arisen by the use of ψ are removed from $c[\phi]$. Notice that the Gricean implementation we discussed above also treated scalar implicatures this way, i.e. everything the speaker could have meant by the alternative ψ is excluded from $c[\phi]$.

Note that the update process with a scalar implicature as represented in (35) is different from updating $c[\phi]$ with 'not ψ', which, given the rule in (17a), would be:

$$c[\phi][\mathtt{not}\ \ \psi] = \{\, \langle w, a\rangle \in c[\phi] \mid \text{there is no } a' \text{ such that } a \preceq a' \text{ and } \langle w, a'\rangle \in c[\phi][\psi] \,\}\,.$$

This would not give us the plurality inference we want. For example, if the relevant excludable alternative to (37) is (37a), then c[(37)][(37a)], which would be required in computing c[(37)][$\mathtt{not}$ (37a)], cannot be computed. This is because the discourse referent x in (37a) is required to be new, but it has already been introduced by (37). Furthermore, if the alternative is understood as introducing a new different discourse referent, say y, as in (37b), then c[(37)][$\mathtt{not}$ (37b)] is bound to be $\emptyset$, because every possibility $\langle w, a\rangle \in c$[(37)] is such that there is at least one pocket in w and that pocket can be a value of y, so every assignment in $\mathsf{A}(c$[(37)]) has an extension in c[(37)][(37b)].

(37) The coat has pockets^x.
  a. The coat has [a pocket]^x
  b. The coat has [a pocket]^y

Furthermore, a moment's reflection reveals that the semantics of *not* in English cannot be understood in terms of subtraction. That is, the alternative negation rule

$$c[\text{not}\ \phi] = c - c[\phi]$$

does not work, because whenever ϕ introduces a new discourse referent, the result of this subtraction operation will be simply vacuous.[22] This means that how alternatives are negated in the computation of scalar implicatures is different from how negation in natural language works. Dynamic semantics is useful in understanding these different notions of 'negation'.

Having dynamicised Exh, let us redefine the notion of excludable alternatives in order to take into consideration the anaphoric dimension of meaning, in addition to the truth-conditional

[22] Note that this rule works in an *eliminative* system (in the sense of Rothschild & Yalcin 2016), where for each sentence ϕ, we have $c[\phi] \subseteq c$. The way we are dealing with discourse referents here makes the system non-eliminative. Although it is not impossible to have discourse referents in an eliminative system, it is not standard in the literature and there are potential empirical issues that I cannot foresee at this point, so I will not pursue this idea here.

dimension of meaning. We do so by using dynamic informativeness, (31), as in (38).[23] To transpose the static version of Exh as faithfully as possible to the current setting, we assume that the relevant notion of informativeness is blind to contextual information.

(38) ψ is an *excludable alternative* to ϕ iff ψ is an alternative to ϕ and ψ is dynamically more informative than ϕ.

We now have all the ingredients necessary for deriving the plurality inference. Take (37) as an example. (37a) is a dynamically more informative alternative, so it is an excludable alternative to (37). In particular, while $\mathsf{W}(c[(37a)]) = \mathsf{W}(c[(37)])$, we have $\mathsf{A}(c[(37a)]) \subset \mathsf{A}(c[(37)])$ (assuming that $\mathsf{A}(c[(37)])$ contains an assignment that assigns a plurality to x; see fn. 19 for cases where it does not). Then the scalar implicature removes all the assignments but those that assign pluralities to x.

Notice that it is crucial that the alternative (37a) introduces the same discourse referent as (37). However, we do not need to restrict relevant alternatives to alternatives with the same discourse referent. That is, even if (37b) counts as an alternative to (37), it is not dynamically more informative, but rather, dynamically independent from (37), so according to the definition of excludable alternatives we are adopting here, it would not count as an excludable alternative. Furthermore, even if it counted as an excludable alternative (e.g. under one of the alternative definitions in fn. 23), the scalar implicature derived with this alternative would be vacuous, because the assignments in $\mathsf{A}(c[(37b)])$ would be all distinct from the assignments in $\mathsf{A}(c[(38)])$ (assuming that y is new with respect to c).

It should also be pointed out that other types of scalar implicatures can be computed in the same way. Since *some* and disjunction are kind of indefinites themselves, let us look at *most*. The following example has a scalar implicature that not all of the professors commute by bike, for which the alternative in (39b) is crucial.

(39) a. Most of the professors commute by bike.
b. All of the professors commute by bike.

Assuming for now that there is no discourse referents for these sentences (but see the next section), their meanings are analysed as (40).

(40) a. $c[$`Most of the professors commute by bike`$]$
$= \{ \langle w, a \rangle \in c \mid \text{the majority of professors commute by bike in } a \}$
b. $c[$`All of the professors commute by bike`$]$
$= \{ \langle w, a \rangle \in c \mid \text{all the professors commute by bike in } a \}$

Since the latter sentence is dynamically more informative than the former, the scalar implicature

---

[23] Another definition that is often found in the literature is 'non-weaker alternatives'. In the current setting, it will look like (i).

(i) ψ is an *excludable alternative* to ϕ iff ψ is an alternative to ϕ and ϕ is not dynamically more informative than ψ.

Obviously, this makes more alternatives excludable We will crucially use this version in Section 6. Furthermore, if one wishes, one could incorporate Fox's (2007) notion of *innocent exclusion*, which will look like (ii).

(ii) a. ψ is *innocently excludable* given ϕ and a set A of alternatives to ϕ iff ψ is a member of a maximal consistent set of excludable alternatives given ϕ and A.
b. $S \subseteq A$ is a *consistent set of excludable alternatives given ϕ and A* iff $\bigcap_{\psi_i \in S}(c[\phi] - c[\psi_i]) \neq \emptyset$

amounts to removing all the possibilities in (40b) from (40a). This amounts to the inference that not all the professors commute by bike. In other words, the present theory can deal with scalar implicatures that arise via a truth-conditionally more informative alternative like this example, as well as scalar implicatures that arise via an anaphorically more informative alternative like the plurality inference. As we will discuss in Section 6, the theory makes an interesting prediction about cases involving an alternative that is both truth-conditionally and anaphorically more informative.

We have now presented two different implementations of the idea of scalar implicatures with discourse referents, a pragmatic implementation and a grammatical implementation. I don't think the empirical phenomenon under discussion provides us with a particularly strong argument for or against either of them, but since the grammatical implementation is formally more detailed and also the theoretical flexibility it makes available will be useful in understanding certain empirical facts discussed in the next section, I will adopt it for the rest of the paper.

4.4 Plural indefinites under negation

We have now waded through all the technicalities necessary to derive the plurality inference as a scalar implicature. Why do we want an account like this? Recall that one of the reasons is because we want to understand why plural nouns stay number-neutral in negative contexts like in the scope of negation, as in (41).

(41) This coat does not have pockets^x.

This is straightforwardly accounted by the present analysis as follows. The alternative to this sentence is (42). We understand it under the narrow scope reading of the indefinite.

(42) This coat does not have [a pocket]^x.

Recall how negation is interpreted, (17a). This rule is formulated so as to block discourse referents introduced in the scope of negation from being accessed from outside the scope of negation (Heim 1982). That is, looking from outside the scope of negation, these sentences look as if they have no discourse referents. In fact, pronominal anaphora fails in both cases as demonstrated in (43).

(43) a. This coat does not have pockets^x. #They$_x$ are outside.
b. This coat does not have [a pocket]^x. #It$_x$ is outside.

This means that (41) and (42) trivially have the same anaphoric properties. Furthermore, it is easy to see that they are truth-conditionally equivalent as well, just like their positive counterparts. Consequently, these sentences are dynamically equivalent, and there is no semantic asymmetry between them. Therefore, no scalar implicature is predicted for (41), capturing the observation that plural nouns are interpreted number-neutrally in the scope of negation.

An obvious prediction of this account is that plural nouns should be interpreted number-neutrally under any operator that similarly shields discourse referents from access from outside. For reasons mentioned at the end of Section 3, I will avoid disjunction and conditionals, but it should be noted that empirical facts suggest that disjunction is not an operator of this type. For instance, the anaphora in (44) is possible (Stone 1992, Rothschild 2017).

(44) Irene has [a cat]^x or [a dog]^x. She loves it$_x$ very much.

Given this observation, our analysis predicts that there should be some plurality inference. This prediction seems to be on the right track in light of examples like (45).

(45) Irene has cats or dogs.

Given the lack of a comprehensive dynamic analysis of disjunction, as well as a proper understanding of sentences with multiple scalar items, I will leave a complete formal account of (45) for future research.

Conditionals similarly involve additional complications. In addition to their inherent intensionality, they are known to license anaphora in modal contexts, as shown in (46).

(46) If Rafael buys [a unicycle]^x, then he will ride it$_x$ every day.
  a. ...He will even use it$_x$ for commuting.
  b. #...It$_x$ is in his office.

Thus, the prediction of our account is that there will be some plurality inference, if not a full-blown one, as anaphora is restricted. However, investigating this further will require us to delve into the complicated issue of modal subordination in addition to the issue of *de re* reference, which I would like to set aside for now. Instead, we will discuss so-called *quantificational subordination* in the next section.

4.5 Partial plurality inferences

Another important empirical motivation for the scalar implicature approach of plurality inference is partial plurality inference. As explained in informal terms at the end of Section 2.3, our explanation for the plurality inference of (47a) is exactly the same as the simple case with a non-quantificational subject. That is, its plurality inference is derived in relation to its singular counterpart in (47b).

(47) a. Exactly one of these coats has pockets^x. (They$_x$ are inside)
  b. Exactly one of these coats has [a pocket]^x (It$_x$ is inside)

We need to wait until the next section to give a proper analysis to the quantifier *exactly one*, but it is already clear that the discourse referent x is accessible in a later discourse, as demonstrated by the continuations in parentheses in (47). Tentatively giving a simple-minded analysis to the quantifier, the meanings of these sentences can be represented as follows.

(48) a. $c[\texttt{Exactly one of these coats has pockets}^x]$

$$= \left\{ \langle w, a[x \mapsto p] \rangle \;\middle|\; \begin{array}{l} \langle w, a \rangle \in c \text{ and} \\ \text{exactly one of the coats has one or more pockets in } w \\ \text{and each atomic part of } p \text{ is a pocket} \\ \quad \text{on the unique coat with one or more pockets in } w \end{array} \right\}$$

  b. $c[\texttt{Exactly one of these coats has [a pocket]}^x]$

$$= \left\{ \langle w, a[x \mapsto p] \rangle \;\middle|\; \begin{array}{l} \langle w, a \rangle \in c \text{ and} \\ \text{exactly one of the coats has one or more pockets in } w \\ \text{and } p \text{ is an atomic pocket} \\ \quad \text{on the unique coat with one or more pockets in } w \end{array} \right\}$$

As in the case of (19) where *this coat* as the subject, the only difference between (48a) and (48b) is whether x can refer to a plurality. Then, (48a) is dynamically less informative than (48b), so by the same reasoning as above, the scalar implicature will be drawn that all possible values of

x are pluralities. We will come back to this example in the next section with a more concrete analysis of the quantifier *exactly one*.

Recall also that there is another type of partial plurality inference, exemplified by (49a). As briefly remarked in Section 2.2, the partial plurality inference of this sentence is presuppositional in nature and makes this sentence infelicitous when (49b) is felicitous.

(49) a. [Every passenger]^x lost their$_x$ suitcases.
 b. [Every passenger]^x lost their$_x$ suitcase.

Again, a proper treatment of quantifiers needs to wait until next section, but the analysis of this partial plurality inference does not hinge on it, since we canăsimply zoom in on how presuppositions work in the present framework. There are different theories of presupposition, but our dynamic semantics is fully compatible with Heim's (1983), so let us adopt it. The intuition behind this theory is that presuppositions are pre-conditions on updates.

In order to apply this idea to the above examples, we obviously cannot sidestep the thorny issue of presupposition projection in quantified sentences. Fortunately for us, it is more or less uncontroversial that universal quantifiers like *every* give rise to *universal presuppositions* (Heim 1983, Chemla 2009, Sudo 2012, 2014, Fox 2012; but see Beaver 2001, Beaver & Krahmer 2001, George 2008), and it is in fact what Heim's theory predicts for these examples, although this only becomes apparent with an analysis of *every*, which needs to wait until next section. Concretely, the presuppositions of the sentences in (49) in the following manner using a distinguished information state # representing the state of presupposition failure.

(50) a. $c[\texttt{[Every passenger]}^x\ \texttt{lost their}_x\ \texttt{suitcases}] \neq \#$ iff for each $\langle w, a\rangle \in c$, $x \notin \mathrm{dom}(a)$ and every passenger in w has one or more suitcases in w.
 b. $c[\texttt{[Every passenger]}^x\ \texttt{lost their}_x\ \texttt{suitcases}] \neq \#$ iff for each $\langle w, a\rangle \in c$, $x \notin \mathrm{dom}(a)$ and every passenger in w has exactly one suitcase in w.

There might be more presuppositions, e.g. the existential presupposition of *every*, but I will omit them here, as they will make no difference. Note that (50b) has a uniqueness presupposition and so its presuppositional condition as described here is simply stronger than that of (50a).

Now, we assume that in a situation like this, a scalar inference is drawn in the domain of presuppositions (Heim 1991, Percus 2006, Heim 2011, Gajewski & Sharvit 2012). It is currently actively debated what exactly is the principle behind it (see, e.g., Spector & Sudo 2017, Marty 2017, Anvari 2019) but let us assume the following principle, which is basically a dynamic version of Spector & Sudo's (2017) idea.

(51) a. ψ is *presuppositionally stronger* than ϕ iff for every c such that $c[\phi] = \#$, $c[\psi] = \#$ and there is at least one c' such that $c'[\psi] = \#$ but $c'[\phi] \neq \#$.
 b. If ϕ has a presuppositionally stronger alternative ψ, then whenever $c[\psi] \neq \#$, $c[\phi]$ is understood as #.

This principle strengthens the presupposition in (50a) with a scalar inference that its singular counterpart must result in #, which is exactly the partial plurality inference in the presuppositional domain (also, as mentioned in fn. 9, this inference could be strengthened with an auxiliary assumption). One could use any of the principles proposed in the works cited above to obtain the same results.

Certainly, this inference is strictly speaking is not a scalar implicature, but it shares the intuition that the inference arises in reference to the singular version of the sentence. Also, its explanation does not require dynamic semantics, as discourse referents are not necessary to derive it and one could use a non-dynamic theory of presupposition, but as demonstrated here, it is fully compatible with our dynamic semantics. I will not come back to this type of partial plurality inference below, but as the reader can easily verify, the enriched system to be discussed in the next section will stay compatible with the above account.

5 Plurality inferences in quantificational contexts

In this section, we will closely examine plurality inferences triggered in quantificational contexts. This will allow us to give a full account of the examples involving *exactly one* and also make predictions about plurality inferences triggered under other quantifiers.

In classical dynamic semantics (Kamp 1981, Heim 1982, Groenendijk & Stokhof 1991), indefinites are the primary means of introducing discourse referents. Subsequent developments in the 1990s (Van den Berg 1996, Chierchia 1995, Kamp & Reyle 1993, Kanazawa 1993, 1994) introduced two important ideas: *selective generalised quantifiers* and *quantificational subordination*. As is well-known, Heim (1982), in particular, made use of the mechanism of *unselective binding* to account for quantificational behaviour of indefinites in donkey sentences, but it was pointed out by Rooth (1987), among others, that it runs into the so-called *proportion problem* for donkey anaphora with quantificational DPs (see Heim 1990, Chierchia 1995, Elbourne 2005, Brasoveanu 2007). In other words, this problem shows that quantificational DPs must be analysed as selective quantifiers.[24]

Another important realisation is that quantifiers interact with discourse referents in intricate ways. Firstly, quantifiers can introduce discourse referents, just like indefinites, as demonstrated by (52).

(52) [Most of the MA students]^x chose Semantics II, instead of Phonology II. It seems that they$_x$ liked Semantics I, but they$_x$ don't know that Semantics II is much more difficult.

Here, the pronouns refer to the MA students that chose Semantics II Clearly this anaphora would not possible were it not for the quantifier in the first sentence, so we have to assume that the crucial discourse referent is introduced by the quantifier. Furthermore, quantifiers interact with discourse referents introduced by other phrases, as illustrated by (53).

(53) [Every student in this class]^x conducted [an original experiment]^y.

a. ...Then they$_x$ each gave a presentation about it$_y$.

b. #...It$_y$ was conducted online.

c. They$_y$ were all conducted online.

Of particular interest is the continuation in (53a). Here, a singular pronoun is used to refer back to each of the experiments the students conducted. Note that this is not possible in (53b), although it is possible to refer back to the plurality consisting of all these experiments with a plural pronoun, as shown by (53c). The contrast between (53a) and (53b) shows that although the discourse referent y is introduced in the scope of the universal quantifier in the first sentence, it can be referenced in a later discourse, *only if it stands in a particular relation with x there*. The idea is that in the first sentence, x ranges across the atomic students under question one by one, and y holds information about what experiment each of them conducted. Then this distributed information can be referenced in a later discourse, only if x is understood distributively there again. In the absence of x, the atomic values of y are shielded and only the totality

[24]Of course, this is only so, if we are to maintain a dynamic analysis of donkey anaphora. Heim (1990) herself pursued a non-dynamic analysis of donkey anaphora, partly as a reply to this problem.

can be accessed, as in (53c). The anaphoric phenomenon exemplified by (53a) is often called *quantificational subordination*.

The current literature on dynamic semantics already contains formal ways of dealing with quantificational subordination with selective quantifiers, so I will just borrow one of them here. What is important for our purposes is that when coupled with the idea of scalar implicatures with discourse referents, the resulting system will make a prediction about sentences like (54).

(54) [Every student in this class]^x conducted [original experiments]^y.

That is, although y is under the scope of a universal quantifier, the discourse referent is still accessible, although in limited ways, as shown above. Since (54) introduces a discourse referent y, we should ask if it has a dynamically more informative alternative, and if it does, it should have a scalar implicature. In order to see what exactly the prediction will be, let us first review how selective quantifiers are defined and how quantificational subordination is accounted for.

5.1 Selective quantifiers

As remarked above, previous research on donkey anaphora converged on the consensus that quantificational DPs need to be analysed as selective quantifiers, if we want to keep a dynamic semantic analysis of the phenomenon. This is not an appropriate place to review the arguments, so I will just introduce one way of defining selective quantifiers in the version of dynamic semantics we have been assuming thus far.[25]

In Classical Generalised Quantifier Theory (Barwise & Cooper 1981, Peters & Westerståhl 2006, among others), a quantificational determiner expresses a relation between two sets, one denoted by the NP and one denoted by the VP. By conservativity, the relation can be seen as a relation between the NP and the intersection of the sets denoted by the NP and VP. These sets are often called the *maxset* and *refset*, respectively.

Selective generalised quantifiers in dynamic semantics will work essentially in the same way, except that the maxset and refset need to be extracted from the dynamic meanings denoted by the NP and VP. Specifically, we will analyse the denotations of NP and VP as dynamic statements, rather than predicates, and a quantificational determiner as an operator over a pair of such dynamic statements. We assume that the syntax generates a representation like (55), where the same variable that appears on the determiner *every* appears in the NP and VP as well.

(55) $\texttt{Every}^x\ [_{\texttt{NP}}\, x\ \texttt{linguist}]\ [_{\texttt{VP}}\, x\ \texttt{laughed}]$

The dynamic statements denoted by the NP and VP are analysed in the same way as before. These variables essentially behave as pronouns without phi-features.

(56) a. $c[x\ \texttt{linguist}] = \{\, \langle w, a\rangle \in c \mid a(x) \text{ is a linguist in } w \,\}$
b. $c[x\ \texttt{laughed}] = \{\, \langle w, a\rangle \in c \mid a(x) \text{ laughed in } w \,\}$

The quantificational determiner, *every* in (55), comes with a variable x, which is assumed to be new. As in the case of indefinites, this condition can be seen as a presupposition, but I won't represent it explicitly here. What the determiner does is that it extracts the set of values of x that satisfy ϕ and the set of values of x that satisfy both ϕ and ψ, which are the maxset and the refset, respectively, and requires that the refset be a subset of the maxset (or equivalently, they are the same set). More specifically, we can analyse the meaning of *every* as follows. For

[25] It should perhaps be noted that it is not very common in the relevant literature to use a Heimian framework where information states are sets.

the sake of simplicity, we tentatively analyse a quantificational determiner to shield discourse referents in its scope from access from outside, which we will fix later. We will write $c[x \mapsto e]$ for $\{ \langle w, a[x \mapsto e] \rangle \mid \langle w, a \rangle \in c \}$.

(57) $c[\mathtt{Every}^x\ \phi\ \psi]$

$$= \left\{ \langle w, a \rangle \in c \;\middle|\; \begin{array}{l} \{ e \in D_e \mid \text{for some } a', \langle w, a' \rangle \in c[x \mapsto e][\phi] \} \\ \subseteq \{ e \in D_e \mid \text{for some } a', \langle w, a' \rangle \in c[x \mapsto e][\phi][\psi] \} \end{array} \right\}$$

Let us unpack this. Since the resulting set is a subset of c in this representation, the condition on the right is about the world component of each possibility. The condition requires that one set of entities to be a subset of another. What are these sets? Notice that $c[x \mapsto e][\phi]$ is the set of possibilities $\langle w', a' \rangle$ where a' is some extension of $a \in \mathsf{A}(c)$ and $a'(x) = e$ (note that no operator can overwrite the value of x in the current system, so nothing in ϕ can reassign a new value to x). There might be other differences between a and a' in case ϕ introduces more discourse referents, but this doesn't concern us. Among these possibilities we are only interested in those whose world component is w. If there is one such possibility, that essentially means that e satisfies the NP meaning ϕ in w. Similarly for $c[x \mapsto e][\phi][\psi]$. Note that ψ is processed after ϕ. This is because ϕ might introduce a discourse referent that can be referenced in ψ, which is basically donkey anaphora.[26] Thus, the set on the left is the set of entities that satisfy ϕ in w and the set on the right is the set of entities that satisfy both ϕ and ψ in w, i.e. they are the maxset and the refset. Note that $c[x \mapsto e]$ may, and usually does, contain other worlds than w. There is a way to redefine the condition in (57) in terms of the subset of c where the world component is w, but we use the formulation in (57) to make the theory compatible with Heim's (1983) theory of presupposition, which requires us to access all relevant worlds at the same time (due to its non-distributivity).

When applied to the above example, where $\phi = x\ \mathtt{linguist}$ and $\psi = x\ \mathtt{laughed}$, this yields:

$$\left\{ \langle w, a \rangle \in c \;\middle|\; \begin{array}{l} \{ e \in D_e \mid e \text{ is a linguist in } w \} \\ \subseteq \{ e \in D_e \mid e \text{ is a linguist and } e \text{ laughed in } w \} \end{array} \right\}.$$

Note in particular:

$$\langle w, a' \rangle \in c[x \mapsto e][x\ \mathtt{linguist}] \text{ iff } e \text{ is a linguist in } w$$
$$\langle w, a' \rangle \in c[x \mapsto e][x\ \mathtt{linguist}][x\ \mathtt{laughed}] \text{ iff } e \text{ is a linguist and laughed in } w$$

It should be easy to see that this amounts to (distributive) universal quantification.

Other quantifiers can be analysed analogously, by changing the relation between the two sets, but we need to be careful with plurality. In particular a significant complication will arise with respect to non-distributivity. For *every*, the NP is normally singular (although it is actually compatible with a plural NP in some cases, as in *every two weeks*), so e in the two sets will always be atomic, forcing the distributive interpretation of the VP, but for quantifiers that are compatible with plural nouns this is not guaranteed. Non-distributive predication in general introduces a lot of complications, which are largely orthogonal to the main purpose of this paper, so I will simplify the discussion below by pretending that all predicates are distributive, i.e. whenever a predicate P is true of an entity a, then P is also true of each atomic part of a, and whenever P is true of a and b, it is also true of $a \oplus b$. This will allow us to simplify the semantics of quantifiers considerably because we can treat them as distributive quantifiers, and dispense with an

[26] Note that (57) derives the so-called existential reading of donkey anaphora. There are several ways of dealing with the universal reading (Kanazawa 1993, 1994, Chierchia 1995, Champollion, Bumford & Henderson 2018). As donkey anaphora is not a main concern in this paper, I will not discuss the universal reading here.

independent distributivity operator (as in Van den Berg 1996, Brasoveanu 2007, 2008, Nouwen 2003, 2007, etc.). See Van den Berg (1996) and Nouwen (2003) for extensive discussions of non-distributive predication in dynamic semantics.

One remaining thing to note about plurality is that what is counted in a quantified statement is the number of atomic elements rather than the number of distinct pluralities. For instance, *Exactly three students are French* does not mean that there are exactly three elements in D_e that are French, which would be true if a, b and $a \oplus b$ are French, and no other entity is. To achieve the correct interpretation, the quantification needs to be over atomic entities, as in (58). Here, D is the domain of the model, which is the set of atomic entities.

(58) $c[\texttt{Exactly three}^x\ \phi\ \psi]$

$$= \left\{ \langle w, a\rangle \in c \;\middle|\; \begin{array}{l} |\,\{\, e \in D \mid \text{for some } a', \langle w, a'\rangle \in c[x \mapsto e][\phi]\,\} \\ \cap \{\, e \in D \mid \text{for some } a', \langle w, a'\rangle \in c[x \mapsto e][\phi][\psi]\,\}\,| = 3 \end{array} \right\}$$

$$= \left\{ \langle w, a\rangle \in c \;\middle|\; |\,\{\, e \in D \mid \text{for some } a', \langle w, a'\rangle \in c[x \mapsto e][\phi][\psi]\,\}\,| = 3 \right\}$$

Finally, we will let the quantificational determiner remember the refset. This is to account for discourse anaphora like (52):

(52) [Most of the MA students]^x chose Semantics II, instead of Phonology II. It seems that they$_x$ liked Semantics I, but they$_x$ don't know that Semantics II is much more difficult.

Since we are limiting ourselves to distributive predication, what is referenced is always the supremum of the refset. This is achieved by the following change to the semantics of *every*. $\bigoplus S$ is the supremum of S in $\langle D_e, \sqsubseteq\rangle$. Note that thanks to the distributivity of S, whenever S is finite and contains at least one plurality, we have $\bigoplus S \in S$ and it the only maximal element in S.

(59) $c[\texttt{Every}^x\ \phi\ \psi]$

$$= \left\{ \langle w, a[x \mapsto d]\rangle \;\middle|\; \begin{array}{l} \langle w, a\rangle \in c \text{ and} \\ M = \{\, e \in D \mid \text{for some } a', \langle w, a'\rangle \in c[x \mapsto e][\phi]\,\} \text{ and} \\ R = \{\, e \in D \mid \text{for some } a', \langle w, a'\rangle \in c[x \mapsto e][\phi][\psi]\,\} \\ \text{and } M \subseteq R \\ \text{and } d = \bigoplus R \end{array} \right\}$$

Van den Berg (1996) and Brasoveanu (2007) use one more variable to register the maxset as well, but this won't be necessary for our purposes. It is easy to generalise (59) to any other quantifier, i.e. all that is needed is to change the fourth line to the relation that the quantifier expresses in Classical Generalised Quantifier Theory.[27]

However, (59) is clearly inadequate, because ϕ and ψ might introduce new discourse referents in them, but they will not be accessible later. In other words, (59) won't enable quantificational subordination. In order to deal with it, we need to introduce more machinery.

[27]Except that negative quantifiers give rise to a problem, as there might not be any individual in the refset. There are several ways of dealing with this issue. For instance, we could conditionalise the last line above on $\{\, e \in D \mid \text{for some } a', \langle w, a'\rangle \in c[x \mapsto e][\phi][\psi]\,\} \neq \emptyset$, so that when this set is empty, no update on a will be performed. Another possible solution is to decompose negative quantifiers into negation and a positive quantifier. A third possibility is to postulate a bottom element in D_e that every predicate is false of (Bylinina & Nouwen 2018). We will not deal with negative quantifiers in our examples, so I will not choose among these solutions. See also Van den Berg (1996), Nouwen (2003) and Buccola & Spector (2016) for other issues of negative quantifiers with non-distributive predication, which cannot be discussed here.

5.2 Quantificational subordination

Let us consider the following example of quantificational subordination again.

(60) [Every student in this class]^x conducted [an original experiment]^y.
They$_x$ each gave a presentation about it$_y$.

The first thing to note is that the most natural reading of the first sentence is that different students conducted different experiments, and this is the reading we are after. On this reading, the second sentence means that each of the students in the class gave a presentation about their own experiment, rather than another student's. This means that in processing the value for y, we need to know which value of x is paired with which value of y.

Van den Berg (1996) proposes an ingenious way to account for quantificational subordination (see also Brasoveanu 2007, 2008, Nouwen 2003). The essential change consists in redefining information states as sets of pairs consisting of a world and a *set of assignments*, rather than a single assignment. Each of the assignments in this set will register one pair of a value of x and a value of y in a given world.

Since this change affects the whole system, we will redefine the basic update rules. The changes necessary for non-quantificational cases are more or less mechanical, as in (61). $A(x)$ denotes $\bigoplus\{\, a(x) \mid a \in A \,\}$.[28]

(61)
a. $c[\texttt{It is raining}] = \{\, \langle w, A\rangle \in c \mid \text{it is raining in } w \,\}$
b. $c[\texttt{She}_x \texttt{ is a linguist}] = c[x \texttt{ is a linguist}]$
$= \{\, \langle w, A\rangle \in c \mid A(x) \text{ is a linguist in } w \,\}$
c. $c[\texttt{They}_x \texttt{ are linguists}]$
$= \{\, \langle w, A\rangle \in c \mid \text{each atomic part of } A(x) \text{ is a linguist in } w \,\}$
d. $c[\texttt{not } \phi]$
$= \{\, \langle w, A\rangle \in c \mid \text{no } a \in A \text{ has an extension } a' \in A' \text{ such that } \langle w, A'\rangle \in c[\phi] \,\}$
e. $c[\phi \texttt{ and } \psi] = c[\phi][\psi]$

Quantifiers will make use of this additional structure. Since we are only dealing with distributive predicates, we continue to treat all quantifiers as distributive quantifiers. As before, an indefinite introduces a new discourse referent, but each assignment a in the set A of assignments will be updated, as illustrated in (62). Here, x is assumed to be a new variable in c, and $a \preceq_x b$ means that b is different from a at most in that $x \in \text{dom}(b)$.

(62) $c[\texttt{Linguists}^x \texttt{ smiled}]$

$$= \left\{ \langle w, B\rangle \;\middle|\; \begin{array}{l} \langle w, A\rangle \in c \text{ and} \\ \text{for each } a \in A \text{ there is } b \in B \text{ such that } a \preceq_x b \text{ and} \\ \text{for each } b \in B \text{ there is } a \in A \text{ such that } a \preceq_x b \text{ and} \\ \text{each atomic part of } B(x) \text{ is a linguist that smiled in } w \end{array} \right\}$$

For a singular indefinite, $B(x)$ must be an atomic entity, which means that all assignments $b \in B$ must map x to the same atomic entity.

(63) $c[[\texttt{A linguist}]^x \texttt{ smiled}]$

[28] As in Brasoveanu (2008) and Dotlačil (2013), but unlike Van den Berg (1996) and Brasoveanu (2007), we assume that an assignment can return a plurality. We ignore presuppositions here, but for instance, $c[\texttt{She}_x \texttt{ is a linguist}] \neq \#$ iff for each $\langle w, A\rangle \in c$ and $A(x)$ is an atomic female entity in w. It should be noted that in the current system, we will never have an information state with a set A of assignments such that for some $a, a' \in A$, $x \in \text{dom}(a)$ but $x \notin \text{dom}(a)$.

$$= \left\{ \langle w, B \rangle \;\middle|\; \begin{array}{l} \langle w, A \rangle \in c \text{ and} \\ \text{for each } a \in A \text{ there is } b \in B \text{ such that } a \preceq_x b \text{ and} \\ \text{for each } b \in B \text{ there is } a \in A \text{ such that } a \preceq_x b \text{ and} \\ B(x) \text{ is a linguist that smiled in } w \end{array} \right\}$$

Similarly, *every* can be analysed as follows. We write $A[x \mapsto e]$ to mean $\{ a[x \mapsto e] \mid a \in A \}$, and $c[x \mapsto e]$ denotes $\{ \langle w, A[x \mapsto e] \rangle \mid \langle w, A \rangle \in c \}$, and $B \preceq A$ means that for each $b \in B$, there is $a \in A$ such that $b \preceq a$.

(64) $c[\texttt{Every}^x\ \phi\ \psi]$

$$= \left\{ \langle w, A \rangle \;\middle|\; \begin{array}{l} M = \{ e \in D \mid \text{for some } B', \langle w, B' \rangle \in c[x \mapsto e][\phi] \} \text{ and} \\ R = \{ e \in D \mid \text{for some } B', \langle w, B' \rangle \in c[x \mapsto e][\phi][\psi] \} \text{ and} \\ M \subseteq R \text{ and} \\ A \subseteq \bigcup_{e \in R} \{ B' \mid \langle w, B' \rangle \in c[x \mapsto e][\phi][\psi] \} \\ \text{and for some } B \text{ such that } \langle w, B \rangle \in c,\ B \preceq A \text{ and} \\ \text{and for each } b \in B, \text{ for each } e \in R, \\ \text{there is exactly one } a \in A \text{ such that } a(x) = e \text{ and } b \preceq a \end{array} \right\}$$

The first three lines are essentially the same as before. The fourth line does the crucial distributive quantification. That is, it universally quantifies over the refset, and collects the results of the updates of ϕ and ψ for each value of x. A needs to be a set of such extended assignments that satisfy the requirements stated in the last three lines: A needs to be an extension of some B in the original information state, and each assignment $b \in B$ must be extended exactly once with respect to each value of the refset. Note that this entails that $A(x) = \bigoplus R$.

This last bit is a little bit complicated, but this complication is partly because we are building the distributivity operator into the quantifier meaning, instead of representing it separately, and partly because we are sticking to the Heimian setup where each information state is a set of possibilities, against which presuppositions are computed. In order to understand how (64) works, let us take an example. The variables x and y are assumed to be new in c.

(65) $c[\texttt{Every}^x\ [_{\text{NP}}\, x\ \texttt{student}]\ [_{\text{VP}}\, x\ \texttt{conducted [an experiment]}^y]]$

$$= \left\{ \langle w, A \rangle \;\middle|\; \begin{array}{l} M = \{ e \in D \mid e \text{ is a student in } w \} \text{ and} \\ R = \left\{ e \in D \;\middle|\; \begin{array}{l} e \text{ is a student that} \\ \quad \text{conducted an experiment in } w \end{array} \right\} \text{ and} \\ M \subseteq R \text{ and} \\ A \subseteq \bigcup_{e \in R} \left\{ B[x \mapsto e][y \mapsto d] \;\middle|\; \begin{array}{l} \langle w, B \rangle \in c \text{ and} \\ d \text{ is an experiment in } w \\ \text{and } e \text{ conducted } d \text{ in } w \end{array} \right\} \\ \text{and } B \preceq A \text{ for some } B \text{ such that } \langle w, B \rangle \in c \\ \text{and for each } b \in B, \text{ for each } e \in R, \\ \text{there is exactly one } a \in A \text{ such that } a(x) = e \text{ and } b \preceq a \end{array} \right\}$$

Suppose that there are exactly two students s_1, s_2 in w_s, and s_1 conducted one experiment e_1, s_2 two experiments e_{21} and e_{22}. Suppose also $\langle w_s, \{ a \} \rangle \in c$. Then, in the output information state, we will have the following possibilities that contain extensions of $\{ a \}$.

$$\left\langle w_s, \left\{ \begin{array}{l} a[x \mapsto s_1][y \mapsto e_1], \\ a[x \mapsto s_2][y \mapsto e_{21}] \end{array} \right\} \right\rangle$$
$$\left\langle w_s, \left\{ \begin{array}{l} a[x \mapsto s_1][y \mapsto e_1], \\ a[x \mapsto s_2][y \mapsto e_{22}] \end{array} \right\} \right\rangle$$

Note importantly that each possibility pairs each student with one experiment that they conducted. This is exactly the information we need to account for quantificational subordination. That is, we analyse the second sentence of the example as follows. To simplify, I will not analyse the indefinite in this sentence.

(66) c[They$_x$ each gave a presentation about it$_y$]

$$= \left\{ \langle w, A \rangle \in c \;\middle|\; \begin{array}{l} \text{for each } e \in D \text{ such that } e \sqsubseteq A(x), \\ \text{the unique } a \in A \text{ such that } a(x) = e \text{ is such} \\ \text{that } a(x) \text{ gave a presentation about } a(y) \text{ in } w \end{array} \right\}$$

Since this part of the example is not of our main concern, I will not dwell on (66). Rather, what is important is that we now have a semantic representation for the first part of the example that has the right amount of anaphoric information.

5.3 Back to partial plurality inferences

Now we are ready to give a full explanation of the partial plurality inference observed with *exactly one*. Applying the general recipe to this quantifier, we obtain (67). Recall that we crucially assume that the plural noun is number-neutral.

(67) c[Exactly one^x [$_{\text{NP}}$ x coat] [$_{\text{VP}}$ x has pockets^y]]

$$= \left\{ \langle w, A \rangle \;\middle|\; \begin{array}{l} M = \{ e \in D \mid e \text{ is a coat in } w \} \text{ and} \\ R = \left\{ e \in D \;\middle|\; \begin{array}{l} e \text{ is a coat} \\ \text{and } e \text{ has one or more pockets in } w \end{array} \right\} \text{ and} \\ |M \cap R| = 1 \text{ (i.e. } |R| = 1) \text{ and} \\ A \subseteq \bigcup_{e \in R} \left\{ B[x \mapsto e][y \mapsto d] \;\middle|\; \begin{array}{c} \langle w, B \rangle \in c \\ \text{and each atomic part of } d \\ \text{is a pocket of } e \text{ in } w \end{array} \right\} \\ \text{and } B \preceq A \text{ for some } B \text{ such that } \langle w, B \rangle \in c \\ \text{and for each } b \in B, \text{ for each } e \in R, \\ \text{there is exactly one } a \in A \text{ such that } a(x) = e \text{ and } b \preceq a \end{array} \right\}$$

Compare this to the version of the sentence with a singular indefinite.

(68) c[Exactly one^x [$_{\text{NP}}$ x coat] [$_{\text{VP}}$ x has [a pocket]^y]]

$$= \left\{ \langle w, A \rangle \;\middle|\; \begin{array}{l} M = \{\, e \in D \mid e \text{ is a coat in } w \,\} \text{ and} \\ R = \left\{ e \in D \;\middle|\; \begin{array}{l} e \text{ is a coat} \\ \text{and } e \text{ has one or more pockets in } w \end{array} \right\} \text{ and} \\ |M \cap R| = 1 \text{ (i.e. } |R| = 1\text{) and} \\ A \subseteq \bigcup_{e \in R} \left\{ B[x \mapsto e][y \mapsto d] \;\middle|\; \begin{array}{l} \langle w, B \rangle \in c \\ d \in D \text{ is a pocket of } e \text{ in } w \end{array} \right\} \\ \text{and } B \preceq A \text{ for some } B \text{ such that } \langle w, B \rangle \in c \\ \text{and for each } b \in B, \text{ for each } e \in R, \\ \text{there is exactly one } a \in A \text{ such that } a(x) = e \text{ and } b \preceq a \end{array} \right\}$$

The only difference between the two sentences is in the values of y. It can be a plurality in (67), not in (68). Let us consider a concrete example information state. Suppose that there are two worlds w_1 and w_2 such that $\langle w_1, \{\, a \,\}\rangle, \langle w_1, \{\, a, b \,\}\rangle, \langle w_2, \{\, b \,\}\rangle \in c$. Suppose further that in w_1, a coat k_1 has exactly one pocket p_1 and no other coat has any pockets. In w_2, a coat k_2 has two pockets, p_{21} and p_{22} and no other coat has any pockets. Then in the output information state of (68), we have the following possibilities.

$$\begin{array}{l} \langle w_1, \{\, a[x \mapsto s_1][y \mapsto p_1] \,\}\rangle \\ \langle w_1, \{\, a[x \mapsto s_1][y \mapsto p_1], b[x \mapsto s_1][y \mapsto p_1] \,\}\rangle \\ \langle w_2, \{\, a[x \mapsto s_2][y \mapsto p_{21}] \,\}\rangle \\ \langle w_2, \{\, a[x \mapsto s_2][y \mapsto p_{22}] \,\}\rangle \end{array}$$

The first possibility here comes from $\langle w_1, \{\, a \,\}\rangle$, the second possibility from $\langle w_1, \{\, a, b \,\}\rangle$, and the last two come from $\langle w_2, \{\, b \,\}\rangle$. In the output information state of (67), on the other hand, there will be more possibilities, because y can be mapped to a plurality. With respect to the above two possibilities, we will get the following five.

$$\begin{array}{l} \langle w_1, \{\, a[x \mapsto s_1][y \mapsto p_1] \,\}\rangle \\ \langle w_1, \{\, a[x \mapsto s_1][y \mapsto p_1], b[x \mapsto s_1][y \mapsto p_1] \,\}\rangle \\ \langle w_2, \{\, a[x \mapsto s_2][y \mapsto p_{21}] \,\}\rangle \\ \langle w_2, \{\, a[x \mapsto s_2][y \mapsto p_{22}] \,\}\rangle \\ \langle w_2, \{\, a[x \mapsto s_2][y \mapsto p_{21} \oplus p_{22}] \,\}\rangle \end{array}$$

Since there are more possibilities in the second case, the plural version of the sentence is dynamically less informative. Drawing the scalar implicature amounts to subtracting all the possibilities that are covered in the first case. Then we are left with the possibilities where y is mapped to a plurality. Note that the possibilities whose world component is w_1 will be eliminated, because y will never be mapped to a plurality there. This means that it will be entailed that the unique coat that has one or more pockets has multiple pockets, which is the plurality inference.

Recall that among the previous theories of the plurality inference, only Spector's (2007) higher-order implicature theory can explain partial plurality inferences of this type. The analysis put forward here is conceptually simpler, as the anaphoric properties of quantifiers are independently attested. Furthermore, our analysis diverges from Spector's with respect to plural nouns occurring under universal quantifiers.

5.4 Plurality inferences under universal quantifiers

The present account makes a prediction about sentences like (69) (fn. 6).

(69) Every coat has pockets.

The predicted plurality inference for this example will be partial, i.e. at least one coat has multiple pockets. Let us see why. We analyse the literal meaning of this sentence as follows.

(70) $c[\texttt{Every}^x\ [_{\texttt{NP}}\, x\ \texttt{coat}]\ [_{\texttt{VP}}\, x\ \texttt{has pockets}^y]]$

$$= \left\{ \langle w, A \rangle \;\middle|\; \begin{array}{l} M = \{ e \in D \mid e \text{ is a coat in } w \} \text{ and} \\ R = \left\{ e \in D \;\middle|\; \begin{array}{l} e \text{ is a coat} \\ \text{and } e \text{ has one or more pockets in } w \end{array} \right\} \text{ and} \\ M \subseteq R \text{ and} \\ A \subseteq \bigcup_{e \in R} \left\{ B[x \mapsto e][y \mapsto d] \;\middle|\; \begin{array}{c} \langle w, B \rangle \in c \\ \text{and each atomic part of } d \\ \text{is a pocket of } e \text{ in } w \end{array} \right\} \\ \text{and } B \preceq A \text{ for some } B \text{ such that } \langle w, B \rangle \in c \\ \text{and for each } b \in B, \text{ for each } e \in R, \\ \text{there is exactly one } a \in A \text{ such that } a(x) = e \text{ and } b \preceq a \end{array} \right\}$$

The singular version of this sentence means (71).

(71) $c[\texttt{Every}^x\ [_{\texttt{NP}}\, x\ \texttt{coat}]\ [_{\texttt{VP}}\, x\ \texttt{has [a pocket]}^y]]$

$$= \left\{ \langle w, A \rangle \;\middle|\; \begin{array}{l} M = \{ e \in D \mid e \text{ is a coat in } w \} \text{ and} \\ R = \left\{ e \in D \;\middle|\; \begin{array}{l} e \text{ is a coat} \\ \text{and } e \text{ has one or more pockets in } w \end{array} \right\} \text{ and} \\ M \subseteq R \text{ and} \\ A \subseteq \bigcup_{e \in R} \left\{ B[x \mapsto e][y \mapsto d] \;\middle|\; \begin{array}{l} \langle w, B \rangle \in c \\ d \in D \text{ is a pocket of } e \text{ in } w \end{array} \right\} \\ \text{and } B \preceq A \text{ for some } B \text{ such that } \langle w, B \rangle \in c \\ \text{and for each } b \in B, \text{ for each } e \in R, \\ \text{there is exactly one } a \in A \text{ such that } a(x) = e \text{ and } b \preceq a \end{array} \right\}$$

It is easy to see that (71) is dynamically more informative than (70). Let us consider a concrete information state. Suppose that $\langle w_1, \{ a \} \rangle, \langle w_2, \{ b \} \rangle, \langle w_2, \{ a, b \} \rangle \in c$. In both of these worlds, there are three coats, k_1, k_2, and k_3. In w_1, k_1 has one pocket p_1, k_2 has two pockets p_{21} and p_{22}, and k_3 has two pockets p_{31} and p_{32}. In w_2, each of them has exactly one pocket, p_1, p_2

and p_3. Then in the output information state in (71), we have the following possibilities:

$$\left\langle w_1, \left\{ \begin{array}{l} a[x \mapsto k_1][y \mapsto p_1], \\ a[x \mapsto k_2][y \mapsto p_{21}], \\ a[x \mapsto k_3][y \mapsto p_{31}] \end{array} \right\} \right\rangle \left\langle w_2, \left\{ \begin{array}{l} b[x \mapsto k_1][y \mapsto p_1], \\ b[x \mapsto k_2][y \mapsto p_2], \\ b[x \mapsto k_3][y \mapsto p_3] \end{array} \right\} \right\rangle$$

$$\left\langle w_1, \left\{ \begin{array}{l} a[x \mapsto k_1][y \mapsto p_1], \\ a[x \mapsto k_2][y \mapsto p_{22}], \\ a[x \mapsto k_3][y \mapsto p_{31}] \end{array} \right\} \right\rangle \left\langle w_2, \left\{ \begin{array}{l} a[x \mapsto k_1][y \mapsto p_1], b[x \mapsto k_1][y \mapsto p_1], \\ a[x \mapsto k_2][y \mapsto p_2], b[x \mapsto k_2][y \mapsto p_2], \\ a[x \mapsto k_3][y \mapsto p_3], b[x \mapsto k_3][y \mapsto p_3] \end{array} \right\} \right\rangle$$

$$\left\langle w_1, \left\{ \begin{array}{l} a[x \mapsto k_1][y \mapsto p_1], \\ a[x \mapsto k_2][y \mapsto p_{21}], \\ a[x \mapsto k_3][y \mapsto p_{32}] \end{array} \right\} \right\rangle$$

$$\left\langle w_1, \left\{ \begin{array}{l} a[x \mapsto k_1][y \mapsto p_1], \\ a[x \mapsto k_2][y \mapsto p_{22}], \\ a[x \mapsto k_3][y \mapsto p_{32}] \end{array} \right\} \right\rangle$$

In the output information state of (70), there are more possibilities, because y can be mapped to a plurality. Thus, in addition to the possibilities above, we also have.

$$\left\langle w_1, \left\{ \begin{array}{l} a[x \mapsto k_1][y \mapsto p_1], \\ a[x \mapsto k_2][y \mapsto p_{21} \oplus_{22}], \\ a[x \mapsto k_3][y \mapsto p_{31}] \end{array} \right\} \right\rangle \left\langle w_1, \left\{ \begin{array}{l} a[x \mapsto k_1][y \mapsto p_1], \\ a[x \mapsto k_2][y \mapsto p_{21} \oplus_{22}], \\ a[x \mapsto k_3][y \mapsto p_{32}] \end{array} \right\} \right\rangle$$

$$\left\langle w_1, \left\{ \begin{array}{l} a[x \mapsto k_1][y \mapsto p_1], \\ a[x \mapsto k_2][y \mapsto p_{21}], \\ a[x \mapsto k_3][y \mapsto p_{31} \oplus p_{32}] \end{array} \right\} \right\rangle \left\langle w_1, \left\{ \begin{array}{l} a[x \mapsto k_1][y \mapsto p_1], \\ a[x \mapsto k_2][y \mapsto p_{22}], \\ a[x \mapsto k_3][y \mapsto p_{31} \oplus p_{32}] \end{array} \right\} \right\rangle$$

$$\left\langle w_1, \left\{ \begin{array}{l} a[x \mapsto k_1][y \mapsto p_1], \\ a[x \mapsto k_2][y \mapsto p_{21} \oplus_{22}], \\ a[x \mapsto k_3][y \mapsto p_{31} \oplus p_{32}] \end{array} \right\} \right\rangle$$

And these additional ones are the ones that will remain after the scalar implicature is computed. Of importance here is the fact that in w_1, k_1 only has one pocket, but w_1 will be in the resulting information state of (70), because w_1 can be mapped with a set of assignments where k_2 and/or k_3 are paired with a plurality of pockets. Generally a world w will remain after the update in (70), if at least one coat has multiple pockets there, because in such a case it can be paired with a set of assignments that its singular counterpart cannot give rise to. Thus, the plurality inference is partial.

It is empirically desirable that this partial plurality inference can be derived, but it should pointed out that the sentence seems to also have a stronger, fully plural reading that every coat has multiple pockets (see Stateva, Andreetta & Stepanov 2016 for experimental evidence for this ambiguity). Under the grammatical implementation of the current analysis, this stronger reading can be derived as a case of embedded implicature, that is derived by applying Exh at the VP-level in the scope of the universal quantifier. Since this type of ambiguity is also observed with other scalar implicatures, e.g. (72), it does not seem to me to be particularly problematic.

(72) Every student has done most of the reading.

However, there is a remaining question about how robust embedded implicatures are in these sentences. It's not necessarily the case that the embedded implicature of (72) is as robust as that of (69), which is a complication that exists in addition to the diversity in robustness observed across scalar items mentioned in Section 2.2. Investigation of this requires more research.

It should also be noted that Spector's (2007) version of the scalar implicature approach predicts the stronger, fully plural reading by default and he introduces an additional assumption, namely that *every* triggers *some* as an alternative, to derive the partial plurality reading.[29] I do not have qualms about this assumption, but it is obvious that our analysis is conceptually much simpler.

6 Disjunction under a universal quantifier

The present analysis makes an interesting prediction about sentences like (73)

(73) Every applicant speaks French or German.

This sentence involves a disjunction that we have been eschewing for reasons mentioned at the end of Section 3.2, but a DP disjunction like this behaves essentially like an existential quantifier with the disjuncts as its domain of quantification, so we can deal with it in the dynamic semantic system at hand.

Our prediction for (73) has some bearing on Crnič, Chemla & Fox's (2015) observation about them. They point out that (72) has a reading whose scalar implicature is that at least one applicant speaks French and at least one applicant speaks German, without implying that not everyone speaks French or that not every one speaks German. That is, the sentence seems to be acceptable and true with respect to a context where every applicant speaks French and a subset of them speak German.

As Crnič et al. point out, this does not follow from a simple theory of scalar implicature (see also Bar-Lev & Fox 2020). It is often assumed that a disjunctive sentence like this has the following alternatives (Sauerland 2004, Spector 2006).

(74) a. Every applicant speaks French.
b. Every applicant speaks German.
c. Every applicant speaks French and German.

Each of these alternative is excludable, but negating (74a) and (74b) will conflict with the reading we are after (although they might be appropriate for a different reading of the sentence; see below).

In order to derive the relevant reading, Crnič et al. make use of embedded implicatures and also crucially assume that certain alternatives can optionally be ignored in the computation of scalar implicatures, a process called *pruning*. More recently, Bar-Lev & Fox (2020) put forward a different analysis that makes use of what they call *innocent inclusion*, but they also need pruning to derive the partial plurality inference.[30] While I will not directly argue against

[29] Similarly, Križ's (2017) homogeneity theory predicts that the default reading is a fully plural reading. He seems to think that in certain contexts the partial plurality reading can be derived, but it seems to me that it also allows a completely number-neutral reading, which does not seem to me to be a reading of (69), but this is probably part of a more general issue of this theory. See fn. 7.

[30] Bar-Lev & Fox (2020) do not explicitly discuss this point, so let me add some details. In order to derive the reading in terms of innocent inclusion, they crucially assume that *every* has *some* as an alternative (cf. Spector's

these analyses here, I would like to point out that by including discourse referents, the reading in question can easily be derived without recourse to pruning.

6.1 Disjunction and maximality

Let us first given an analysis to the DP disjunction *French or German*. Although I cannot give a general analysis of disjunction here, we can regard this DP disjunction as an existential quantifier. First, note that it introduces a discourse referent, as shown in (75).

(75) Daniel speaks [French or German]^y. He learned it$_y$ at high school.

A disjunction in an unembedded context like this generally has two types of implicature: an *ignorance implicature* that the speaker is not sure if Daniel speaks French and the speaker is not sure if Daniel speaks German; and an *exclusivity implicature* that the speaker is certain that Daniel does not speak both of these languages. In the following discussion the ignorance implicature will not play a big role, as the reading of (73) we are interested in does not have an ignorance implicature. So let us focus on the exclusivity implicature.

The exclusivity implicature arises from the conjunctive alternative in (76).

(76) Daniel speaks [French and German]^y. (He learned them$_y$ at high school.)

As shown in the parentheses, this conjunctive DP introduces a discourse referent. The following simple analysis is enough to account for its anaphoric properties.

(77) c`[Daniel speaks [French and German]`^{y}

$$= \left\{ \langle w, A[y \mapsto \text{French} \oplus \text{German}]\rangle \;\middle|\; \begin{array}{l} \langle w, A\rangle \in c \text{ and Daniel speaks} \\ \text{both French and German in } w \end{array} \right\}$$

If we analysed the disjunction in (75) as an indefinite, as in (78), however, we would not be able to derive the exclusivity inference.

(78) c`[Daniel speaks [French or German]`^{y}`]`

$$= \left\{ \langle w, B\rangle \;\middle|\; \begin{array}{l} \text{for some } \langle w, A\rangle \in c, \\ \text{for each } a \in A \text{ there is } b \in B \text{ such that } a \preceq_y b \text{ and} \\ \text{for each } b \in B \text{ there is } a \in A \text{ such that } a \preceq_y b \text{ and} \\ \text{each atomic part of } B(y) \text{ is French or German} \\ \quad \text{and Daniel speaks each atomic part of } B(y) \text{ in } w \end{array} \right\}$$

Given this analysis, the alternative in (77) is dynamically more informative, so it should give rise to a scalar implicature, but it is actually not strong enough to give us the exclusivity inference.

2007 analysis of the partial plurality inference mentioned above). Then in addition to the alternatives in (74), we will also have the following as alternatives.

(i) a. Some applicant speaks French.
   b. Some applicant speaks German.
   c. Some applicant speaks French and German.

The crucial effect of this is that (ia) and (ib) make (74a) and (74b) non-excludable, as they assume innocent exclusion as their notion of excludability and (ia) and (ib) bring in symmetry to block exclusion of (74a) and (74b). However, notice that (ic) is still excludable so we will derive the scalar implicature that no applicant speaks both French and German, but it conflicts with the reading we are after. Thus, to derive this reading, they after to assume that (ic) can be pruned, without pruning (ia) and (ib).

This is due to the non-maximality of indefinites discussed iin Section 3.4 which results in too many possibilities. Essentially, the alternative in (77) is too specific to be able to exclude all of the ones that we want to exclude. Concretely, suppose that $\langle w_{fg}, \{\, a \,\}\rangle \in c$ such that Daniel speaks both French and German in w_{fg}. Then the update with the conjunctive alternative (77) will extend this possibility to:

$$\langle w_{fg}, \{\, a[y \mapsto \text{French} \oplus \text{German}] \,\}\rangle\,.$$

On the other hand, (77) will yield two more possibilities, because indefinites are non-maximal.

$$\begin{array}{l}\langle w_{fg}, \{\, a[y \mapsto \text{French} \oplus \text{German}] \,\}\rangle \\ \langle w_{fg}, \{\, a[y \mapsto \text{French}] \,\}\rangle \\ \langle w_{fg}, \{\, a[y \mapsto \text{German}] \,\}\rangle\end{array}$$

The scalar implicature will remove the top possibility, but the latter two will remain. This means that after the computation of the scalar implicature, we will still have w_{fg} in the resulting information state, so we are not excluding the possibility that Daniel speaks both French and German. But what we want to derive as the exclusivity inference is that he certainly doesn't speak both.

In order to derive the exclusivity inference, we need to assume that the DP disjunction has maximality. That is, it only introduces the top possibility in the above representation. This is achieved by the following analysis.

(79) c[`Daniel speaks [French or German]`^{y}]

$$= \left\{ \langle w, B\rangle \;\middle|\; \begin{array}{l} \text{for some } \langle w, A\rangle \in c, \\ \text{for each } a \in A \text{ there is } b \in B \text{ such that } a \preceq_y b \text{ and} \\ \text{for each } b \in B \text{ there is } a \in A \text{ such that } a \preceq_y b \text{ and} \\ \text{Daniel speaks French and/or German in } w \text{ and} \\ \text{if Daniel speaks both of them in } w, \\ \quad \text{for each } b \in B,\ b(y) \text{ is French}\oplus\text{German, and} \\ \text{if Daniel speaks French but not German in } w, \\ \quad \text{for each } b \in B,\ b(y) \text{ is French, and} \\ \text{if Daniel speaks German but not French in } w, \\ \quad \text{for each } b \in B,\ b(y) \text{ is German} \end{array} \right\}$$

This has maximality in the sense that for each world where Daniel speaks at least one of the languages, y stores the maximal entity among French, German, and French⊕German that DAniel speaks in that world. Generally, selective generalised quantifiers have maximality in the present system, as they require the refset to be covered by the values of the variable they are associated with, so this essentially means that DP disjunction is analysed as an existential quantifier, rather than as an indefinite.

6.2 Distributivity Inference

Let us now see what the theory predicts for (73). By combining our analysis of *every* and DP disjunction, we obtain (80).

(80) c[`Every`^{x} [$_{\text{NP}}$ x `applicant`] [$_{\text{VP}}$ x `speaks [French or German]`^{y}]]

$$= \left\{ \langle w, A \rangle \;\middle|\; \begin{array}{l} M = \{\, e \in D \mid e \text{ is an applicant in } w \,\} \text{ and} \\ R = \left\{ e \in D \;\middle|\; \begin{array}{c} e \text{ is an applicant and } e \text{ speaks} \\ \text{French and/or German in } w \end{array} \right\} \text{ and} \\ M \subseteq R \text{ and} \\ A \subseteq \bigcup_{e \in R} \left\{ B[x \mapsto e][y \mapsto d] \;\middle|\; \begin{array}{l} \langle w, B \rangle \in c \\ \text{if } e \text{ speaks French and German in } w, \\ \quad d \text{ is French} \oplus \text{German} \\ \text{if } e \text{ speaks French but not German in } w, \\ \quad d \text{ is French} \\ \text{if } e \text{ speaks German but not French in } w, \\ \quad d \text{ is German} \end{array} \right\} \\ \text{and } B \preceq A \text{ for some } B \text{ such that } \langle w, B \rangle \in c \\ \text{and for each } b \in B, \text{ for each } e \in R, \\ \text{there is exactly one } a \in A \text{ such that } a(x) = e \text{ and } b \preceq a \end{array} \right\}$$

The conjunctive alternative (74c) will mean (81).

(81) c`[Every`^{x} `[`$_{\text{NP}}$ x `applicant] [`$_{\text{VP}}$ x `speaks [French and German]`^{y}`]]`

$$= \left\{ \langle w, A \rangle \;\middle|\; \begin{array}{l} M = \{\, e \in D \mid e \text{ is an applicant in } w \,\} \text{ and} \\ R = \left\{ e \in D \;\middle|\; \begin{array}{c} e \text{ is an applicant and } e \text{ speaks} \\ \text{French and German in } w \end{array} \right\} \text{ and} \\ M \subseteq R \text{ and} \\ A \subseteq \bigcup_{e \in R} \left\{ B[x \mapsto e][y \mapsto d] \;\middle|\; \begin{array}{l} \langle w, B \rangle \in c \\ d \text{ is French} \oplus \text{German} \\ \text{and } e \text{ speaks } d \text{ in } w \end{array} \right\} \\ \text{and } B \preceq A \text{ for some } B \text{ such that } \langle w, B \rangle \in c \\ \text{and for each } b \in B, \text{ for each } e \in R, \\ \text{there is exactly one } a \in A \text{ such that } a(x) = e \text{ and } b \preceq a \end{array} \right\}$$

This is dynamically more informative than (80), so it will give rise to a scalar implicature. This scalar implicature will remove $\langle w, A[y \mapsto \text{French} \oplus \text{German}] \rangle$ where every applicant speaks both languages in w. Concretely, whenever $\langle w_{FG}, A \rangle \in c$ such that every applicant speaks both languages in w_{FG}, (81) will give rise to the possibility $\langle w_{FG}, A' \rangle$ where for each $a' \in A'$, $a'(y) = \text{French} \oplus \text{German}$. This is the only type of possibilities that can be found in the output information state of (81). With respect to the same $\langle w_{FG}, A \rangle \in c$ (80) will give rise to exactly the same possibilities as its conjunctive alternative, so after the scalar implicature is computed, there will no world like w_{FG} where every applicant speaks both languages.

We have two more alternatives. The alternative in (74a) is analysed as (82). As in the case of a conjoined DP, we assume *French* introduces a discourse referent, as it feeds pronominal anaphora.

(82) c`[Every`^{x} `[`$_{\text{NP}}$ x `applicant] [`$_{\text{VP}}$ x `speaks French`^{y}`]]`

$$= \left\{ \langle w, A \rangle \;\middle|\; \begin{array}{l} M = \{\, e \in D \mid e \text{ is an applicant in } w \,\} \text{ and} \\ R = \left\{ e \in D \;\middle|\; \begin{array}{c} e \text{ is an applicant and } e \text{ speaks} \\ \text{French in } w \end{array} \right\} \text{ and} \\ M \subseteq R \text{ and} \\ A \subseteq \bigcup_{e \in R} \left\{ B[x \mapsto e][y \mapsto \text{French}] \;\middle|\; \begin{array}{l} \langle w, B \rangle \in c \\ e \text{ speaks French in } w \end{array} \right\} \\ \text{and } B \preceq A \text{ for some } B \text{ such that } \langle w, B \rangle \in c \\ \text{and for each } b \in B, \text{ for each } e \in R, \\ \text{there is exactly one } a \in A \text{ such that } a(x) = e \text{ and } b \preceq a \end{array} \right\}$$

This is actually neither dynamically more informative nor dynamically less informative. This is because it can introduce possibilities that cannot be introduced by (80). That is, with respect to if $\langle w_{FG}, A \rangle \in c$ such that every applicant speaks both languages in w_{FG}, (82) will give rise to the possibility $\langle w_{FG}, A' \rangle$ where for each $a' \in A'$, $a'(y) = \text{French}$, which is not possible for (80) due to maximality. Furthermore, the output information state of the latter can include possibilities that do not exist in the output information state of (82), e.g. $\langle w_{fg}, A' \rangle$ where some applicants speak only French and the others only speak German in w_{fg}. Therefore, the two sentences are dynamically independent.

Let us assume crucially that a scalar implicature can be computed from such a dynamically independent alternative. As noted in fn. 23, this is achieved by changing the definition of excludable alternatives from those that are dynamically more informative to those that are not dynamically less informative. Then (82) will be excludable. Now, let us consider which possibilities will be removed by the scalar implicature it triggers. In both output information states we can find the following three kinds of worlds: worlds w_F where everyone speaks French, worlds w_{Fg} where everyone speaks French but only some speak German, and w_{FG} where everyone speaks both. As remarked above, all the possibilities with w_{FG} will be removed by the conjunctive alternative, so we can ignore them. If $\langle w_F, A \rangle \in c$, then (82) will map this to $\langle w_F, A' \rangle \in c$ such that for each $a' \in A'$, $a(y) = \text{French}$, and so does (80), because that's the maximal value. Then, all such possibilities $\langle w_F, A' \rangle \in c$ will be removed by the scalar implicature, meaning that we have the inference that it's not the case that everyone speaks only French, which is good.

Crucially, we do not remove all the possibilities involving w_{Fg}. This is because the two sentences will create different possibilities out of $\langle w_{Fg}, A \rangle$. Specifically, (82) will map it to $\langle w_{Fg}, A' \rangle$ where each $a' \in A'$ is such that $a'(y) = \text{French}$, but (80) will map it to $\langle w_{Fg}, A'' \rangle$ where for some $a'' \in A''$, $a'(y) = \text{French} \oplus \text{German}$, when $a'(x)$ speaks both languages in w_{Fg}. This means therefore, there will be some possibilities left in the output information whose world component is w_{Fg}, so the scalar implicature will not entail that not every applicant speaks French.

By the same reasoning on the alternative (74b), we obtain the inference that not every applicant only speaks German. Thus, overall, the read amounts to: every applicant speaks at least one of French and German, and the following are all false: every applicant only speaks French, every applicant only speaks German, and every applicant both of them. This is compatible with every applicant speaking French as long as if only some of them speak German as well, and with every applicant speaking German, as long as only some of them speak French as well. Notice in particular that we do not need pruning or any extra machinery like embedded implicature or innocent inclusion to derive this reading. The crucial ingredient is the discourse referents, which makes the alternatives more informative than usually assumed, thereby making their 'negations' weaker than usually assumed.

There is a remaining question about whether we also want to derive a reading that entails that not every applicant speaks French and that not every applicant speaks German. The two previous analyses, **?** and Bar-Lev & Fox (2020), actually derive this stronger reading by default. Under the present account, it cannot be derived as a separate reading, but I am notăcompletely certain if it is actually a separate reading. That is, the inference that not everyone speaks French and not every speaks German follows from the reading we derived together with an additional assumption that everyone speaks at most one of them. At this point I do not think there is conclusive evidence that the stronger partial plurality inference needs to be represented separately. I will therefore leave this potential issue for my analysis open for now.

Relatedly, Bar-Lev & Fox (2020) observe that only the stronger partial plurality inference is available when the universal quantifier is a universal modal, as in (83).

(83) Daniel is required to speak French or German (at the interview).

The partial plurality inference here amounts to the negations of all the following alternatives.

(84) a. Daniel is required to speak French.
b. Daniel is required to speak German.
c. Daniel is required to speak French and German.

Bar-Lev & Fox (2020) conjecture that this difference between universal DP quantifiers and universal modals arises because the latter does not introduce existential modals as alternatives in this case. Our analysis might be able to account for it by capitalising on the fact that the modal blocks anaphora, as shown in (85).

(85) Daniel is required to speak [French or German]^x at the interview. ??Nathan spoke it$_x$.

If there is no discourse referents, then the present theory predicts the negations of (84) to be the scalar implicatures. However, one complication here is that modals give rise to a restricted form of anaphora called *modal subordination*, like (86).

(86) Daniel is required to speak [French or German]^x at the interview. The interviewer will ask some simple questions in it$_x$.

Thus, the prediction of the theory needs to be evaluated carefully with respect to modal subordination. I will leave this for future research.

Lastly, the account offered here is much more limited in its empirical scope, as I have not offered a general semantics for disjunction, while distributivity inferences are observed with all kinds of disjunction, not just with DP disjunction. Extending the present account to such cases will require considerable change in the system, as the anaphoric mechanism will have to be generalised to all semantic types. I will leave this for future research.

7 Conclusion

As far as I know, this is the first paper that systematically explores the idea that scalar implicatures can be computed relative to the anaphoric dimension of meaning, which is represented in terms of discourse referents. As I have mentioned multiple times, this is a particularly natural idea given Grice's (1989) intuition that scalar implicatures are drawn from alternatives that could have been more informative (or not less informative), and given the fact that discourse referents carry information. I presented one formal implementation of this idea couched in dynamic semantics, and discussed its consequences in one empirical domain, the plurality inference of plural nouns in English. The resulting system does not give us a lot of empirical gain, in comparison to Spector's (2007) higher-order implicature theory, but it is certainly not worse in this regard, and is conceptually simpler (if not technically), as I remarked in several places. Furthermore, the theoretical value of the proposal goes beyond this one empirical phenomenon, as it concretely demonstrates the validity and usefulness of the idea of scalar implicatures with discourse referents, which has hitherto been unjustifiably poorly investigated. I hope to explore further consequences of this idea in other empirical domains in future research.

References

Anand, Pranav, Caroline Andrews, Donka Farkas & Matthew Wagers. 2011. The exclusive interpretation of plural nominals in quantificational environments. In *Proceedings of SALT 21*, 176–196.

Anvari, Amir. 2019. *Aspects of Contextual Enrichment*: Ecole Normale Supérieure dissertation.

Bale, Alan & David Barner. 2009. The interpretation of functional heads: Using comparatives to explore the mass/count distinction. *Journal of Semantics* 26(3). 217–252. doi:10.1093/jos/ffp003.

Bale, Alan, Michaël Gagnon & Hrayr Khanjian. 2011. On the relationship between morphological and semantic markedness. *Morphology* 21(2). 197–221. doi:10.1007/s11525-010-9158-1.

Bar-Lev, Moshe & Danny Fox. 2020. Free choice, simplification, and Innocent Inclusion. *Natural Language Semantics* 28. 175–223. doi:10.1007/s11050-020-09162-y.

Barner, David & Jesse Snedeker. 2005. Quantity judgments and individuation: evidence that mass nouns count. *Cognition* 97(1). 41–66. doi:10.1016/j.cognition.2004.06.009.

Barwise, Jon & Robin Cooper. 1981. Generalized quantifiers and natural language. *Linguistics and Philosophy* 4(2). 159–219.

Beaver, David. 2001. *Presupposition and Assertion in Dynamic Semantics*. Stanford: CSLI.

Beaver, David & Emiel Krahmer. 2001. A partial account of presupposition projection. *Journal of Logic, Language, and Information* 10(2). 147–182. doi:10.1023/A:1008371413822.

van den Berg, Martin. 1996. *Some Aspects of the Internal Structure of Discourse: The Dynamics of Nominal Anaphora*: Universiteit van Amsterdam Ph.D. dissertation.

Bergen, Leon, Roger Levy & Noah Goodman. 2016. Pragmatic reasoning through semantic inference. *Semantics & Pragmatics* 9(20). 1–83. doi:10.3765/sp.9.20.

Brasoveanu, Adrian. 2007. *Structured Nominal and Modal Reference*: Rutgers University Ph.D. dissertation.

Brasoveanu, Adrian. 2008. Donkey pluralities: plural information states versus non-atomic individuals. *Linguistics and Philosophy* 31(2). 129–209. doi:10.1007/s10988-008-9035-0.

Breheny, Richard, Nathan Klinedinst, Jacopo Romoli & Yasutada Sudo. 2018. The symmetry problem: current theories and prospects. *Natural Language Semantics* 26(2). 85–110. doi: https://doi.org/10.1007/s11050-017-9141-z.

Buccola, Brian & Benjamin Spector. 2016. Modified numerals and maximality. *Linguistics and Philosophy* 39. 151–199. doi:0.1007/s10988-016-9187-2.

Bylinina, Lisa & Rick Nouwen. 2018. On “zero” and semantic plurality. *Glossa* 3(1). 98. doi:10.5334/gjgl.441.

Champollion, Lucas, Dylan Bumford & Robert Henderson. 2018. Donkeys under discussion. To appear in Semantics and Pragmatics.

Charlow, Simon. 2014. *On the Semantics of Exceptional Scope*: New York University dissertation.

Chemla, Emmanuel. 2008. An epistemic step for anti-presuppositions. *Journal of Semantics* 25(2). 141–173. doi:10.1093/jos/ffm017.

Chemla, Emmanuel. 2009. Similarity: towards a unified account of scalar implicatures, free choice permission and presupposition projection. Ms.

Chemla, Emmanuel & Benjamin Spector. 2011. Experimental evidence for embedded scalar implicatures. *Journal of Semantics* 28(3). 359–400. doi:10.1093/jos/ffq023.

Chierchia, Gennaro. 1995. *Dynamics of Meaning: Anaphora, Presupposition, and the Theory of Grammar*. Chicago: University of Chicago Press.

Chierchia, Gennaro. 1998. Plurality of mass nouns and the notion of 'semantic parameter'. In Susan Rothstein (ed.), *Events and Grammar*, 53–103. Dordrecht: Kluwer.

Chierchia, Gennaro. 2004. Scalar implicatures, polarity phenomena, and the syntax/pragmatics interface. In Adriana Belletti (ed.), *Structures and Beyond: The Cartography of Syntactic Structures*, 39–103. Oxford: Oxford University Press.

Chierchia, Gennaro. 2010. Mass nouns, vagueness and semantic variation. *Synthese* 174(1). 99–149. doi:10.1007/s11229-009-9686-6.

Chierchia, Gennaro, Danny Fox & Benjamin Spector. 2012. Scalar implicature as a grammatical phenomenon. In Claudia Maienborn, Klaus von Heusinger & Paul Portner (eds.), *Semantics: An International Handbook of Natural Language Meaning*, 2297–2331. Berlin: de Gruyter.

Clifton, Charles & Chad Dube. 2010. Embedded implicatures observed: a comment on Geurts and Pouscoulous (2009). *Semantics & Pragmatics* 3(7). 1–13. doi:10.3765/sp.3.7.

Crnič, Luka, Emmanuel Chemla & Danny Fox. 2015. Scalar implicatures of embedded disjunction. *Natural Language Semantics* 23(4). 271–305. doi:10.1007/s11050-015-9116-x.

Cummins, Chris. 2014. Typicality made familiar: A commentary on Geurts and van Tiel (2013). *Semantics & Pragmatics* 7(8). 1–15. doi:10.3765/sp.7.8.

Dotlačil, Jakub. 2013. Reciprocals distribute over information states. *Journal of Semantics* 30(4). 423–477. doi:10.1093/jos/ffs016.

Égré, Paul & Mikaël Cozic. 2016. Conditionals. In Maria Aloni & Paul Dekker (eds.), *The Cambridge Handbook of Formal Semantics*, 490–524. Cambridge: Cambridge University Press. doi:10.1017/CBO9781139236157.018.

van Eijck, Jan. 2001. Incremental dynamics. *Journal of Logic, Language, and Information* 10(3). 319–351. doi:10.1023/A:1011251627260.

Elbourne, Paul. 2005. *Situations and Individuals*. Cambridge, MA: MIT Press.

Evans, Gareth. 1980. Pronouns. *Linguistic Inquiry* 11(2). 337–362.

Farkas, Donka & Henriëtte de Swart. 2010. The semantics and pragmatics of plurals. *Semantics & Pragmatics* 3. 1–54.

Fox, Danny. 2007. Free choice and the theory of scalar implicatures. In Uli Sauerland & Penka Stateva (eds.), *Presupposition and Implicature in Compositional Semantics*, 71–112. Palgrave Macmillan.

Fox, Danny. 2012. Presupposition projection from quantificational sentences: trivalence, local accommodation, and presupposiiton strengthening. In Ivano Caponigro & Carlo Cecchetto (eds.), *From Grammar to Meaning: The Spontaneous Logicality of Language*, 201–232. Cambridge: Cambridge University Press. Ms., MIT and HUJI.

Fox, Danny & Martin Hackl. 2006. The universal density of measurement. *Linguistics and Philosophy* 29(5). 537–586. doi:10.1007/s10988-006-9004-4.

Fox, Danny & Roni Katzir. 2011. On the characterization of alternatives. *Natural Language Semantics* 19(1). 87–107. doi:10.1007/s11050-010-9065-3.

Fox, Danny & Roni Katzir. 2020. Notes on interated rationality models of scalar implicatures. Ms., MIT and Hebrew University of Jerusalem.

Franke, Michael. 2011. Quantity implicatures, exhaustive interpretation, and rational conversation. *Semantics and Pragmatics* 4(1). 1–82. doi:10.3765/sp.4.1.

Franke, Michael & Leon Bergen. 2020. Theory-driven statistical modeling for semantics and pragmatics: A case study on grammatically generated implicature readings. *Language* 96(2). 77–96. doi:10.1353/lan.2020.0034.

Franke, Michael, Fabian Schlotterbeck & Petra Augurzky. 2017. Embedded scalars, preferred readings and prosody: An experimental revisit. *Journal of Semantics* 34(1). 153–199. doi:10.1093/jos/ffw007.

Gajewski, Jon & Yael Sharvit. 2012. In defense of the grammatical approach to local implicatures. *Natural Language Semantics* 20(1). 31–57. doi:10.1007/s11050-011-9074-x.

George, Benjamin. 2008. A new predictive theory of presupposition projection. In *Proceedings of SALT 18*, 358–375.

Geurts, Bart. 2008. Implicture as a discourse phenomenon. In *Proceedings of Sinn und Bedeutung 11*, 261–275.

Geurts, Bart. 2009. Scalar implicature and local pragmatics. *Mind & Language* 24(1). 51–79. doi:10.1111/j.1468-0017.2008.01353.x.

Geurts, Bart & Nausicaa Pouscoulous. 2009. Embedded implicatures?!? *Semantics and Pragmatics* 2(4). 1–34. doi:10.3765/sp.2.4.

Geurts, Bart & Bob van Tiel. 2013. Embedded scalars. *Semantics & Pragmatics* 6(9). 1–37. doi:10.3765/sp.6.9.

Grice, Paul. 1989. *Studies in the Way of Words*. Cambridge, MA: Harvard University Press.

Grimm, Scott. 2013. Plurality is distinct from number-neutrality. In *Proceedings of NELS 41*, .

Groenendijk, Jeroen & Martin Stokhof. 1990. Dnamic Montague Grammar. In Lauri Karttunen & Laszlo Polos (eds.), *Proceedings of the 2nd Symposium on Logic and Language*, 3–48. Budapest: Eotvos Lorand University Press.

Groenendijk, Jeroen & Martin Stokhof. 1991. Dynamic Predicate Logic. *Linguistics and Philosophy* 14(1). 39–100. doi:10.1007/BF00628304.

Gutzmann, Daniel. 2015. *Use-Conditional Meaning: Studies in Multidimensional Semantics*. Oxford: Oxford University Press.

Gutzmann, Daniel & Eric McCready. 2016. Quantification with pejoratives. In Rita Finkbeiner, Jörg Meibauer & Heike Wiese (eds.), *Pejoration*, 75–102. Amsterdam: John Benjamins.

Heim, Irene. 1982. *The Semantics of Definite and Indefinite Noun Phrases*: University of Massachusetts, Amherst Ph.D. dissertation.

Heim, Irene. 1983. On the projection problem for presuppositions. In *WCCFL 2*, 114–125.

Heim, Irene. 1990. E-type pronouns and donkey anaphora. *Linguistics and Philosophy* 13(2). 137–177. doi:10.1007/BF00630732.

Heim, Irene. 1991. Artikel und Definitheit. In Arnim von Stechow & Dieter Wunderlich (eds.), *Semantik: Ein internationales Handbuch der zeitgenössischen Forschung/Semantics: An International Handbook of Contemporary Research*, 487–535. Berlin: de Gruyter.

Heim, Irene. 2011. Definiteness and indefiniteness. In Klaus von Heusinger, Claudia Maienborn & Paul Portner (eds.), *Semantics: An International Handbook of Natural Language Meaning*, vol. 2, 996–1025. Berlin: de Gruyter.

Horn, Laurence. 1989. *A Natural History of Negation*. Chicago: Chicago University Press.

Ivlieva, Natalia. 2013. *Scalar Implicatures and the Grammar of Plurality and Disjunction*: Massachusetts Institute of Technology dissertation.

Ivlieva, Natalia. 2014. Multiplicity and non-monotonic environments. In Luka Crnič & Uli Sauerland (eds.), *The Art and Craft of Semantics: A Festschrift for Irene Heim*, vol. 1, 245–251. Cambridge, MA: MITWPL. https://semanticsarchive.net/Archive/

jZiNmM4N/.
Ivlieva, Natalia. 2020. Dependent plurality and the theory of scalar implicatures: Remarks on Zweig 2009. *Journal of Semantics* 37(3). 425–454. doi:10.1093/jos/ffaa004.
Kamp, Hans. 1981. A theory of truth and semantic representation. In Jeroen A. G. Groenendijk, Theo M. V. Janssen & Martin J. B. Stokhof (eds.), *Formal Methods in the Study of Language*, 277–322. Amsterdam: Mathematical Center.
Kamp, Hans & Uwe Reyle. 1993. *From Discourse to Logic: An Introduction to Modeltheoretic Semantics in Natural Language, Formal Logic and Discourse Representation Theory*. Dordrecht: Kluwer Academic Publishers.
Kanazawa, Makoto. 1993. Dynamic generalized quantifiers and monotonicity. Tech. rep. ILLC.
Kanazawa, Makoto. 1994. Weak vs. strong readings of donkey sentences and monotonicity inferences in a dynamic setting. *Linguistics and Philosophy* 17(2). 109–158. doi:10.1007/BF00984775.
Karttunen, Lauri. 1976. Discourse referents. In James D. McCawley (ed.), *Syntax and Semantics 7: Notes from the Linguistic Underground*, 363–385. New York: Academic Press.
Karttunen, Lauri & Stanley Peters. 1979. Conventional implicature. In Choon-Kyu Oh & David Dinneen (eds.), *Syntax and Semantics 11: Presupposition*, 1–56. New York: Academic Press.
Katzir, Roni. 2007. Structurally-defined alternatives. *Linguistics and Philosophy* 30(6). 669–690. doi:10.1007/s10988-008-9029-y.
Kaufmann, Magdalena & Stefan Kaufmann. 2015. Conditionals and modality. In Shalom Lappin & Chris Fox (eds.), *The Handbook of Contemporary Semantic Theory*, 237–270. New York: Wiley.
Križ, Manuel. 2017. Bare plurals, multiplicity, and homogeneity. Ms., Institut Jean Nicod.
Landman, Fred. 2000. *Events and Plurality*. Dordrecht: Kluwer.
Lima, Suzi. 2018. New perspectives on the count–mass distinction: Understudied languages and psycholinguistics. *Language and Linguistics Compass* 12(11). 1–20. doi:10.1111/lnc3.12303.
Link, Godehard. 1983. The logical analysis of plurals and mass terms: A lattice theoretical approach. In Rainer Bäuerle, Christoph Schwarze & Arnim von Stechow (eds.), *Meaning, Use, and the Interpretation of Language*, 302–323. Berlin: Mouton de Gruyter.
Magri, Giorgio. 2009a. *A Theory of Individual-Level Predicates Based on Blind Mandatory Implicatures. Constraint Promotion for Optimality Theory*: MIT dissertation.
Magri, Giorgio. 2009b. A theory of individual-level predicates based on blind mandatory scalar implicatures. *Natural Language Semantics* 17(3). 245–297. doi:10.1007/s11050-009-9042-x.
Mandelkern, Matthew & Daniel Rothschild. 2019. Definiteness projection. *Natural Language Semantics* 28. 77–109. doi:10.1007/s11050-019-09159-2.
Martí, Luisa. 2018. Inclusive plurals and the theory of number. Ms., Queen Mary University of London.
Marty, Paul, Jacopo Romoli, Yasutada Sudo & Richard Breheny. 2020. Negative Free Choice. Ms. UCL and the University of Bergen.
Marty, Paul P. 2017. *Implicatures in the DP Domain*: Massachusetts Institute of Technology dissertation.
Mayr, Clemens. 2015. Plural definite NPs presuppose multiplicity via embedded exhaustification. In *Proceedings of SALT 25*, 204–224.
McCready, Eric. 2010. Varieties of Conventional Implicatures. *Semantics and Pragmatics* 3.
Meyer, Marie-Christine & Roman Feiman. 2020. Priming reveals similarities and differences between three purported cases of implicature: Some, number and free choice disjunctions.

Ms. https://psyarxiv.com/6b4v3/.

Muskens, Reinhard. 1996. Combining Montague Semantics and Discourse Representation. *Linguistics and Philosophy* 19(2). 143–186.

Nouwen, Rick. 2003. *Plural Pronominal Anaphora in Context: Dynamic Apsects of Quantification*: Utrecht Institute of Linguistics OTS Ph.D. dissertation.

Nouwen, Rick. 2007. On dependent pronouns and dynamic semantics. *Journal of Philosophical Logic* 36(2). 123–154. doi:10.1007/s10992-006-9029-8.

Pearson, Hazel, Manizeh Khan & Jesse Snedeker. 2010. Even more evidence for the emptiness of plurality: An experimental investigation of plural interpretation as a species of implicature. In *Proceedings of SALT 20*, 489–508.

Percus, Orin. 2006. Antipresuppositions. Tech. rep. Japan Society for the Promotion of Science. Report of the Grant-in-Aid for Scientific Research (B), Project No. 15320052.

Peters, Stanley & Dag Westerståhl. 2006. *Quantifiers in Language and Logic*. Oxford: Oxford University Press.

Postal, Paul. 1966. On so-called 'pronouns' in english. In Francis Dinneen (ed.), *Report on the Seventeeth Annual Round Table Meeting on Linguistics and Language Studies*, 177–206. Washington, D.C.: Georgetown University Press.

Potts, Christopher. 2005. *The Logic of Conventional Implicatures*. Oxford: Oxford University Press.

Potts, Christopher. 2007. The dimensions of quotation. In Christopher Barker & Pauline Jacobson (eds.), *Direct Compositionality*, 405–431. Oxford: Oxford University Press.

Potts, Christopher, Daniel Lassitert, Roger Levy & Michael C. Frank. 2016. Embedded implicatures as pragmatic inferences under compositional lexical uncertainty. *Journal of Semantics* 33(4). 755–802. doi:10.1093/jos/ffv012.

Romoli, Jacopo. 2012. *Soft But Strong: Neg-Raising, Soft Triggers, and Exhaustification*: Harvard University dissertation.

Rooth, Mats. 1987. Noun Phrase Interpretation in Montague Grammar, File Change Semantics, and Situation Semantics. In Peter Gärdenfors (ed.), *Generalized Quantifiers: Linguistic and Logical Approaches*, 237–268. Dordrecht: Reidel.

Rothschild, Daniel. 2017. A trivalent approach to anaphora and presupposition. In *Proceedings of the Amsterdam Colloquium 2017*, .

Rothschild, Daniel & Seth Yalcin. 2016. Three notions of dynamicness in language. *Linguistics and Philosophy* 39(4). 333–355. doi:DOI10.1007/s10988-016-9188-1.

Rothstein, Susan. 2017. *Semantics for Counting and Measuring*. Cambridge: Cambridge University Press.

Sauerland, Uli. 2003. A new semantics for number. In Robert B. Young & Yuping Zhou (eds.), *Proceedings of SALT 13*, 258–275. Ithaca, NY: Cornell Linguistics Club.

Sauerland, Uli. 2004. Scalar implicatures in complex sentences. *Linguistics and Philosophy* 27(3). 367–391. doi:10.1023/B:LING.0000023378.71748.db.

Sauerland, Uli. 2008. Implicated presuppositions. In Anita Steube (ed.), *The Discourse Potential of Underspecified Structures* Language, Context and Cognition, 581–600. Berlin: Mouton de Gruyter.

Sauerland, Uli, Jan Anderssen & Kazuko Yatsushiro. 2005. The plural is semantically unmarked. In Stephan Kepser & Marga Reise (eds.), *Linguistic Evidence*, 409–430. Berlin: Mouton de Gruyter.

Schwarzschild, Roger. 1996. *Pluralities*. Dordrecht: Kluwer.

Singh, Raj. 2019. Context, content, and the occasional costs of implicature computation. *Frontiers in Psychology* 10. 2214. doi:10.3389/fpsyg.2019.02214.

Spector, Benjamin. 2006. *Aspects de la pragmatique des operateurs logiques*: Université Paris 7, Denis Diderot dissertation.

Spector, Benjamin. 2007. Aspects of the pragmatics of plural morphology: On higher-order implicatures. In Uli Sauerland & Penka Stateva (eds.), *Presuppositions and Implicatures in Compositional Semantics*, 243–281. New York: Palgrave-Macmillan.

Spector, Benjamin. 2016. Comparing exhaustivity operator. *Semantics & Pragmatics* 9(11). doi:http://dx.doi.org/10.3765/sp.9.11.

Spector, Benjamin & Yasutada Sudo. 2017. Presupposed ignorance and exhaustification: how scalar implicatures and presuppositions interact. *Linguistics and Philosophy* 40(5). 473–517. doi:https://doi.org/10.1007/s10988-017-9208-9.

Stalnaker, Robert. 1989. On the representation of context. *Journal of Logic, Language, and Information* 7(1). 3–19.

Stateva, Penka, Sara Andreetta & Arthur Stepanov. 2016. On the nature of the plurality inference: Ladybugs for Anne. In Ludivine Dupuy, Adrianna Grabizna, Nadège Foudon & Pierre Saint-Gernier (eds.), *Papers Dedicated to Anne Reboul*, Lyon: CNRS. http://reboul.isc.cnrs.fr/.

Stone, Matthew. 1992. *Or* and anaphora. In *Proceedings of SALT 2*, 367–385.

Sudo, Yasutada. 2012. *On the Semantics of Phi Features on Pronouns*: Massachusetts Institute of Technology Ph.D. dissertation.

Sudo, Yasutada. 2014. Presupposition projection in quantified sentences and cross-dimensional anaphora. Ms., UCL.

Sudo, Yasutada. 2016. The existential problem of scalar implicatures and anaphora across alternatives. In Christopher Pi non (ed.), *Empirical Issues in Formal Syntax and Semantics 11*, 225–244. http://www.cssp.cnrs.fr/eiss11/index_en.html.

van Tiel, Bob. 2014. Embedded scalars and typicality. *Journal of Semantics* 31(2). 147–177. doi:10.1093/jos/fft002.

van Tiel, Bob, Emiel van Miltenburg, Natalia Zevakhina & Bart Geurts. 2016. Scalar diversity. *Journal of Semantics* 33(1). 137–175.

van Tiel, Bob, Ira A. Noveck & Mikhail Kissine. 2018. Reasoning with 'some'. *Journal of Semantics* 35(4). 757–797. doi:10.1093/jos/ffy012.

van Tiel, Bob, Elizabeth Pankratz & Chao Sun. 2019. Scales and scalarity: Processing scalar inferences. *Journal of Memory and Language* 105. 93–107. doi:10.1016/j.jml.2018.12.002.

Tieu, Lyn, Cory Bill, Jacopo Romoli & Stephen Crain. to appear. Testing theories of plural meanings: Insights from acquisition. *Cognition* .

Tieu, Lyn & Jacopo Romoli. 2019. Plurality. In Chris Cummins & Napoleon Katsos (eds.), *The Oxford Handbook of Experimental Semantics and Pragmatics*, 208–227. Oxford: Oxford University Press. doi:10.1093/oxfordhb/9780198791768.013.22.

von Fintel, Kai. 2011. Conditionals. In Klaus von Heusinger, Claudia Maienborn & Paul Portner (eds.), *Semantics*, 1515–1538. Berlin: de Gruyter.

von Fintel, Kai. 2012. Subjunctive conditionals. In Gillian Russell & Della Graff Fara (eds.), *The Routledge Comparion to Philosophy of Language*, 466–477. New York: Routledge.

Winter, Yoad. 2000. Distributivity and dependency. *Natural Language Semantics* 8(1). 27–69. doi:10.1023/A:1008313715103.

Zweig, Eytan. 2009. Number-neutral bare plurals and the multiplicity implicature. *Linguistics and Philosophy* 32(4). 353–407. doi:10.1007/s10988-009-9064-3.