Ten men and women got married today

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Abstract

The word *and* can be used both intersectively, as in *John lies and cheats*, and collectively, as in *John and Mary met*. Research has tried to determine which one of these two meanings is basic. Focusing on coordination of nouns (*liar and cheat*), this paper argues that the basic meaning of *and* is intersective. This theory has been successfully applied to coordination of other kinds of constituents (Partee and Rooth, 1983; Winter, 2001). Certain cases of collective coordination (*cat and dog*, *men and women*) are considered a challenge for this view, and for this reason the collective theory has been argued to be superior (Heycock and Zamparelli, 2005). The main result of this paper is that the intersective theory actually predicts the collective behavior of *and* in these cases, due to the way it interacts with certain silent operators involving set minimization and choice functions. These operators are believed to be present in the grammar on the basis of phenomena involving indefinites and collective predicates, and they have been argued to cause collective interpretations in coordinations of noun phrases (Winter, 2001). This paper also shows that the collective theory does not generalize to coordinations of noun phrases in the way it was suggested by its proponents.

Keywords: coordination, plurality, collectivity, choice functions, hydras

1 Introduction: How to deal with liars and cheats

The word *and* can be used both intersectively, as in the sentences in (1), and collectively, as in the sentences in (2). This paper focuses on conjunctive coordination of nouns in English, which also shows both intersective and collective behavior. For example, sentences (1a) and (1b) both talk about a person in the intersection of the sets denoted by the predicates *liar* and *cheat*, while sentences (2a) and (2b) both talk about a collective entity formed by a male and a female person.

(1) a. John **lies and cheats**. *(intersective)*
b. That **liar and cheat** can not be trusted. *(intersective)*

(2) a. **John and Mary** met in the park last night. *(collective)*

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b. A **man and woman** met in the park last night. *(collective)*

Conjunction of plural nouns shows similar behavior, as shown by the following examples by Heycock and Zamparelli (2005). For example, sentence (3) is about two people each of whom is both a friend and a colleague of mine, while the most prominent reading of sentence (4) is about a collective entity formed by a number of men and a number of women, and totaling ten.

(3) My two **friends and colleagues** wrote their paper together. *(intersective)*

(4) Ten **men and women** got married today in San Pietro. *(collective)*

In some cases, a given sentence can be ambiguous between an "intersective" and a "collective" reading. Heycock and Zamparelli call the former a "joint" and the latter a "split" reading. For example, sentence (5) below can either be understood as making a narrow claim about every linguist-philosopher – the "joint" reading – or as making a claim about every linguist and every philosopher – the "split" reading (Winter, 1998).

(5) Every linguist and philosopher knows the Gödel Theorem.
  a. Everyone who is both a linguist and a philosopher knows the Gödel Theorem.
  b. Every linguist knows the Gödel Theorem, and every philosopher knows the Gödel Theorem.

A major theme in research on coordination has been the quest for a lexical entry that unifies these two uses. This amounts to determining whether the basic meaning of *and* is related to intersection, or whether it is based on formation of collective individuals. I will refer to the former view as the intersective theory. It is developed in several places early on (von Stechow, 1974; Gazdar, 1980; Partee and Rooth, 1983). As for the latter view, I will it the collective theory. It is adopted, for example, by Krifka (1990) and by Heycock and Zamparelli (2005). Some authors also assume that *and* is lexically ambiguous between an intersective and a collective use (e.g., Link, 1983, 1984; Hoeksema, 1988). I will call this the ambiguity theory. Many authors refer to the intersective theory as *boolean conjunction* and to the collective theory as *non-boolean conjunction*, presumably because there is a close connection between intersection and the meet operation, particularly in boolean algebras (Keenan and Faltz, 1985). However, there are proposals in which *and* denotes a meet operation that is not limited to boolean models (Barker, 2010). Additionally, the collective theory is often couched in terms of classical extensional mereology, whose models are isomorphic to complete boolean algebras with the bottom element removed (Tarski, 1935; Pontow and Schubert, 2006). So the connection between the term pairs "boolean"/"non-boolean" and "intersective"/"collective" is not straightforward. For this reason, I will continue to call the two theories "intersective" and "collective".

The ambiguity theory does not capture the intuitive connection between the intersective and collective uses, and furthermore it does not capture the crosslinguistic connection between these uses. The typological generalization is that many languages have coordinations with collective and intersection-based uses, no languages have coordinations with collective and union-based uses (Payne, 1985). In other words, there are no known languages with a coordination that can also be used to form collective individuals but that otherwise has the behavior of a disjunction. One of the goals of theories of coordination is to account for this generalization, as also argued by Winter (2001). The generalization is not explained by the ambiguity theory, so the only two options that remain are the intersective theory and the collective theory.

The purpose of this paper is to argue for the intersective theory, that is, for the view that *and* invariably denotes (generalized) intersection. This theory immediately delivers the intersective behavior of *and*, as in (1). For example, the coordination in (1b) is a case of predicate intersection: the set denoted by *liar and cheat* is the intersection of the sets denoted by *liar* and by *cheat*. As for the collective behavior of coordination, as in (2) and in (4), I will show that it emerges as a consequence of the interaction of *and* with a series of independently motivated silent operators. Although the focus of this paper is not on the distribution of these operators, the present proposal is compatible with the view that they are silent syntactic heads whose distribution is constrained by syntax, following Winter (2001). An alternative would be to regard them as semantic composition rules akin to type shifters that are invisible to the syntactic component of the grammar. For an accessible discussion of the difference between the two perspectives and some putative psycholinguistic and neurolinguistic correlates, see Pylkkänen (2008).

In a nutshell, I will argue that coordinations like *man and woman* are interpreted collectively because the two nouns are interpreted in the same way as the two conjoined noun phrases in *a man and a woman*. This does not mean that, syntactically speaking, *man and woman* in (2b) is a noun phrase or a conjunction of noun phrases. Rather, it is a conjunction of nominals and is therefore itself a nominal. So the constituents *man and woman* and *a man and a woman* have different syntactic status even though at one point in the derivation of the former, it has the same meaning as the latter.

The perspective advocated here is that collectively interpreted noun-noun conjunction, semantically though not syntactically speaking, amounts to conjunction of indefinites. In a sentence like (2b), the conjoined nominal happens to be itself contained in an indefinite noun phrase. But collective noun-noun conjunction can also occur inside a definite noun phrase, as the following corpus example shows (emphasis mine):

(6) He has been completely impervious to the political winds swirling around him, and we have had our storms. For all of that, **this committee and country** owe him a great debt of gratitude.... [1]

I will argue that even in such cases, the conjuncts are indefinite, in the sense that the two nouns introduce variables that are bound by existential quantifiers. The reason that this does not show up in the truth conditions of the sentence is that the existential quantifiers are "masked", so to speak, by the demonstrative definite determiner *this* that takes scope over them. An arguably similar effect that does not involve coordination can be observed in German and English sentences. A numeral that can be used by itself as an indefinite determiner is used in the scope of a demonstrative determiner in the following example, a newspaper headline (Zander, 2013) that refers to the actor Peter O'Toole and the movie *Lawrence of Arabia*) and in its English translation:

(7) Um berühmt zu werden, reichte ihm dieser eine Film.
PRT famous to become, sufficed him this one film.
"This one film was all he needed to become famous."

[1] Taken from the Corpus of Contemporary American English (Davies, 2008). Date: 1997 (19970118), Title: THE GINGRICH CASE; Remarks Opening Ethics Committee's Hearing on the Gingrich Case, Author: By The New York Times, Source: New York Times

The German singular numeral *ein* appears here in its weak declension form *eine* because it follows a definite determiner. Just like its English counterpart *one*, it can occur in adjectival position in the scope of a determiner. If that determiner is definite as is the case here, the truth conditions of the sentence no longer reflect the indefiniteness of *ein*. Also just like its English counterpart, *ein* can occur by itself. As a modification of the previous example shows, its indefiniteness then becomes apparent:

(8) Um berühmt zu werden, reichte ihm ein Film.
PRT famous to become, sufficed him one film.
"One film was all he needed to become famous."

This kind of example may serve as motivation for the suggestion that some indefinites can be placed in the scope of definite determiners and that in those cases their indefiniteness can no longer be observed in the truth conditions of the sentence. The null assumption is that if overt indefinites can do this, so can covert ones, and I will adopt this assumption in what follows. The semantic analysis of adjectival *one* itself is not the topic of this paper. If it was, we would want to analyze and explain the semantic contribution of adjectival *one*.

Sentences involving coordination of plurals, such as (4), offer an additional wrinkle as they involve counting-related issues. In English, a noun phrase like *five men and women* can either involve reference to a group of five people that includes some men and some women, or to a group of ten people of which five are men and five are women (Dalrymple, 2004; King and Dalrymple, 2004). These two readings are attested in (9) and (10), respectively.

(9) *Five men and women* from four states have been elected to serve on the University of Iowa Foundation Board of Directors. At its October meeting, the Foundations Board of Directors elected ... [list of five names][2]

(10) *Five men and women,* representing the five military services, will learn who becomes the 1995 winners when the U.S. Military Sports Association announces the male and female winners here Jan. 19. In the mens category, the candidates are ... [list of five names]. Competing for the female athlete of the year are ... [list of five names][3]

I will focus on the first reading this paper, so let me briefly address the second reading here. This reading arguably shows the ability of the numeral *five* to be interpreted twice, separately in each conjunct. This idea might be implemented, for example, via syntactic deletion of the numeral or via some semantic equivalent of it. With a syntactic deletion account, the noun phrase in (10) would be analyzed as underlyingly involving a second copy of *five*, like this:

(11) five men and ~~five~~ women

A semantic implementation of this idea is found in Cooper (1979) and further discussed in various places (Partee and Rooth, 1983; Dowty, 1988; Winter, 1998). Here is an illustration of Cooper's idea for a singular conjunction *this man and woman.* Here, **this** is a function from sets to generalized quantifiers.

[2]From `www.uifoundation.org/news/1999/dec05.shtml`, cited in Dalrymple (2004).
[3]From `www.defenselink.mil/news/Jan1996/n010419969601043.html`, cited in Dalrymple (2004).

(12) a. $[\![\text{man}]\!] = \lambda D.D(\mathbf{man})$
b. $[\![\text{woman}]\!] = \lambda D.D(\mathbf{woman})$
c. $[\![\text{man and woman}]\!] = [\lambda D.D(\mathbf{man}) \cap \lambda D.D(\mathbf{woman})]$
$= \lambda D.[D(\mathbf{man}) \cap D(\mathbf{woman})]$
d. $[\![\text{this man and woman}]\!]$
$= \lambda D.[D(\mathbf{man}) \cap D(\mathbf{woman})](\mathbf{this})$
$= [\mathbf{this}(\mathbf{man}) \cap \mathbf{this}(\mathbf{woman})]$

This line of analysis involves raising the type of each noun so that it expects the determiner as an argument, then intersecting the two raised nouns, and finally combining them with the determiner. It is straightforward to adapt this analysis to the ten-people reading of *five men and women* illustrated in (10). Since this derivation involves intersection, this reading does not represent a challenge to the intersective theory. Indeed, Rooth's derivation shows that even singular noun-noun coordination could be handled that way in principle, at least when the verb phrase is interpreted distributively.

I will concentrate instead on the five-people reading illustrated in (9). That reading does not seem to be amenable either by a determiner deletion analysis or to a determiner raising analysis in the style shown above. So it is the five-people reading that represents the true challenge for the intersective theory. I develop such an analysis in the remainder of the paper.

There is another reason to think that determiner deletion and determiner raising are only able to cover part of the picture, and it has to do with hydras. A hydra is a multiply-headed relative clause. This construction was named and discussed in Link (1984). The following example is taken from that source:

(13) The man and woman who dated each other are friends of mine.

Several facts are remarkable about this example, besides the fact that it includes an instance of collective noun-noun coordination. First, the predicate *who dated each other* is collective, so its denotation must apply to a collective individual rather to a man and a woman separately. Second, the presupposition of the definite descriptions is intertwined with the meaning of the hydra. It is acceptable to utter the example in a situation where there is no unique man and there is no unique woman, as long as there is a unique man-woman couple who dated each other. In that respect, the sentence is similar to the following one:

(14) The couple who dated each other are friends of mine.

The only difference to the previous sentence, of course, is that there is no noun-noun coordination anymore here but a collective noun which seems to mean the same. It seems that in (13), the nominal *man and woman* denotes the same as the nominal *couple* in (14). The two nominals seem to play the same role vis-à-vis the relative clause: both denote properties of collective individuals that are intersected with the property of collective individuals denoted by the relative clause. The two also seem to play the same role vis-à-vis the determiner, since it is this intersection that is presupposed to contain one unique collective individual. These observations suggest that the nominal in hydras denotes a property of collective individuals that is of the same type as the relative clause (so that they can be intersected). Since the relative clause is plausibly a property of collective individuals, and since Cooper's analysis in (12) represents the nominal as a property of determiner denotations, we conclude that Cooper's analysis cannot be the only one available, and that there must be an analysis on which *man and woman* denotes a property of collective individuals.

At this point the reader might think that the collective theory has a clear advantage, since it is easy on that theory to let *man and woman* denote such a property. This can be done by pointwise collective formation, as in the following entry, where $\oplus$ denotes collective formation and can (but need not) be thought of as mereological sum or fusion (Link, 1983; Krifka, 1990):

(15) $$[\![\text{and}_{coll}]\!] = \lambda P_{et} \lambda Q_{et} \lambda x. \exists y \exists z [P(y) \wedge Q(z) \wedge x = y \oplus z]$$

This entry has the effect that a predicate P *and* Q holds of an entity x iff x can be divided into two parts y and z, such that $P(y)$ and $Q(z)$ hold. These "parts" are understood here as the members of a collective individual. For example, when this entry is applied to *man* and *woman*, it returns the set of all collective individuals consisting of a man and a woman. Indeed, Link (1984) applies this rule to hydra constructions. If this was the only application of coordination in language, we could stop here and adopt the collective theory. Instead, I will pursue the intersective theory, in spite of the fact that the cards seem to be stacked against it. To sum up the evidence so far, hydras suggest that *man and woman* denotes a property of couples, and since the determiner-raising analysis is incompatible with hydras and does not predict the "five-people" reading of *five men and women*.

The main result of this paper is that the intersective theory actually predicts the collective behavior of *and*, both in the case of hydras, and in the "five-people reading" as well as in the "ten-people reading" of plural coordination. , due to the way it interacts with certain silent operators involving set minimization and choice functions. These operators are believed to be present in the grammar on the basis of phenomena involving indefinites and collective predicates, and they have been argued to cause collective interpretations in coordinations of noun phrases (Winter, 2001). As is discussed below (Section 5), problems with the collective theory arise once we try to adopt it to precisely the case in which the intersective theory has the fewest problems, namely coordination of generalized quantifiers.

For the purpose of exposition, I will start with the case of coordination of singular nouns. But the ultimate goal is to account for the "five-people reading" of the plural coordination *five men and women*, as in (9). The analysis I will develop sits peacefully side by side with the determiner-raising analysis, because both will assume the same lexical entry for *and* and therefore both are compatible with the intersective theory. When applied to coordination of singular nouns, both analyses will generally yield the same truth conditions. It is only once we apply them to coordination of plural nouns that they will come apart, with each of the two readings of *five men and women* being predicted by one of the two analyses.

The rest of this paper is organized as follows. The next section introduces the framework of Winter (2001) and shows how to apply it to a coordination of two singular nouns denoting disjoint sets: *man and woman*. Essentially, we will apply a silent operator to each of these nouns whose meaning is akin to *some*, when interpreted as a generalized quantifier. When the two sets have the potential to overlap, as in *doctor and lawyer*, the generalized-quantifier approach to the silent operator needs to be complemented with a choice-functional approach. This is done in section 3. The final step in the development of the analysis, in section 4, is to consider coordination of plural nouns, as in the title of this paper. Section 5 is a comparison with previous work. It focuses on a thoroughly developed implementation of the collective theory, namely Heycock and Zamparelli (2005). I show that in contrast to what Heycock and Zamparelli suggest, their implementation does not generalize to coordinations of noun phrases in the way they intend it to. Section 5 also discusses the account of Winter (1998), who gives a pair-forming denotation to *and*, in a similar way to alternative semantic treatments of *or*. This approach has been recently revived and generalized by Szabolcsi (2013). The relationship between *and* and *or* on the present account is dealt with in section 6, where the typological facts discussed above are also explained. After a partial analysis of the hydra construction in section 7, I summarize the main results of the paper in section 8.

2 Man and woman: the last obstacle to intersective coordination

The general strategy of the following analysis is to assume that *and* has just one lexical entry, which is intersective, and to derive the intersective/collective ambiguity from the optional presence of silent syntactic elements, and not as a lexical ambiguity of *and*. On this view, all sentences with noun-noun coordination are in principle ambiguous, but this ambiguity only shows up in a few sentences like the Gödel sentence (5). In most cases only one of the readings will surface, due to world knowledge and plausibility considerations. For example, sentences involving the coordination *man and woman* lack the intersective reading because nobody is both a man and a woman, perhaps apart from unlikely cases (hermaphrodites).

The intersective theory requires us to assume that *and* always combines with two constituents that it can intersect in some way. This will not always be possible. For example, two ordinary individuals cannot be meaningfully intersected. So the intersective theory assumes that *and* is only able to conjoin constituents of the right types. Formally, we identify falsity with the empty set, and truth with any other set, as in von Neumann arithmetic. Then conjunction of truth values can be modeled as intersection (Gazdar, 1980). This covers the case of sentential coordination. I will represent conjunction of truth values as the Schönfinkeled function $\wedge_{\langle t,tt\rangle}$. (I write $\alpha\beta$ as an abbreviation of $\langle\alpha,\beta\rangle$. So $\langle t,tt\rangle$ stands for $\langle t,\langle t,t\rangle\rangle$. This means that $\wedge$ is a function that takes its two arguments one at a time.) Now define a boolean type as being either t or a type of the shape $\langle\alpha,\beta\rangle$ where α is any type whatsoever and β is a boolean type. This corresponds to what is called a "conjoinable type" in Partee and Rooth (1983); I follow Winter (2001) in calling it a boolean type. Intuitively, a boolean type is one that "ends in t". For example, if proper names are taken to denote ordinary individuals, they are of type e and cannot be conjoined because e is not a boolean type. In that case, we need to shift them to another type. One way to do this is the "Montague lift". This lift is defined in (16) and maps an individual to the set of all the sets that contain this individual (Partee and Rooth, 1983). This set is of type $\langle et,t\rangle$, which is a boolean type. So we cannot conjoin two proper names directly but we can conjoin their Montague lifts.

(16) **Montague lift:** $\lambda x_e \lambda P_{\langle et\rangle}.P(x)$

The starting point for my implementation of the intersective theory is the assumption that *and* always has the meaning in (17), suggested among others by Gazdar (1980) and Partee and Rooth (1983). A paraphrase follows. This is probably the most obvious way to generalize intersective *and* from the sentential to the subsentential case. The formulation of this entry is taken from Winter (2001). Here and in what follows, I use τ as a variable that ranges over boolean types, and I use σ_1 and σ_2 as variables that range over any type.

(17) $$[\![\text{and}_{bool}]\!] = \sqcap_{\langle\tau,\tau\tau\rangle} =_{def} \begin{cases} \wedge_{\langle t,tt\rangle} & \text{if } \tau = t \\ \lambda X_\tau \lambda Y_\tau \lambda Z_{\sigma_1}.X(Z) \sqcap_{\langle\sigma_2,\sigma_2\sigma_2\rangle} Y(Z) & \text{if } \tau = \langle\sigma_1,\sigma_2\rangle \end{cases}$$

Roughly, this entry says that a conjunction of sentences S_1 *and* S_2 is true whenever both of the conjuncts are true, and a conjunction of subsentential constituents C_1 *and* C_2 denotes their intersection. For example, this entry says that in the case of $\tau = \langle et\rangle$, which is the relevant case for noun-noun coordination, *and* has the following denotation:

(18) **Noun coordination:** $[\![\text{and}_{bool}]\!] = \lambda P_{et} \lambda P'_{et} \lambda x_e.P(x) \wedge_{\langle t,tt\rangle} P'(x)$

When this function is applied to two predicates P and P', it returns the characteristic function of the intersection of the characteristic set of P with the characteristic set of P'. Since it is often easier to speak of the effect of (17) in terms of intersection of sets than in terms of the corresponding operation on characteristic functions and characteristic sets, I will often equivocate between sets and functions. Thus, when the function in (18) is applied to two sets P and P', it returns the intersection of these two sets. For a more detailed explanation of the entry in (17), see for example Partee and Rooth (1983).

The implementation of the intersective theory I will develop builds on the one by Winter (2001). In that monograph, there is no discussion of noun-noun coordination. An earlier version of that work takes noun-noun coordination to require a departure from the intersective theory Winter (1998). I discuss the relation of the present work to that theory in Section 5. In the following, by "Winter" I refer to Winter (2001) unless otherwise stated. Winter shows that the intersective theory is viable in related cases such as noun phrase coordination. In particular, he shows how the intersective theory is compatible with the collectivity effect in the verb phrase of (2a), repeated here as (19).

(19) John and Mary met in the park last night.

Winter's account relies on the insight that one can use the minimizer in (20) to "distill" any intersection or union of principal ultrafilters into a set of sets of their generators.

(20) **Minimizer:** $\min =_{def} \lambda Q_{\tau t} \lambda A_\tau.\ A \in Q \wedge \forall B \in Q[B \subseteq A \rightarrow B = A]$

For example, the conjunction of the generalized quantifiers that are obtained by Montague-lifting the two constants corresponding to *John* and *Mary* is the predicate $\lambda P.P(j) \sqcap \lambda P.P(m)$. Expressed in terms of sets, the intersection $\{P \mid j \in P\} \cap \{P \mid m \in P\}$ is the set of all properties that hold both of John and of Mary. The result of applying the minimizer in (20) to this set is $\{\{j, m\}\}$. Following Winter, I represent collective individuals as (nonempty) sets. This allows us to view this set as the property of being the collective individual consisting of John and Mary, one of the two properties involved in sentence (19). The application of the minimizer is accompanied by a conceptual shift: its input is a generalized quantifier, and its output is a property of collective individuals. The shift is conceptual because mathematically speaking, both its input and its output are functions of the same type ($\langle et, t\rangle$), and both are isomorphic to sets of sets of individuals. Winter's system contains a syntactic component that constrains the places in which the minimizer may and may not apply, but this will not concern us here.

The other property involved in sentence (19) is denoted by the verb phrase and is a property of sets who met in the park last night. The meaning of (19) can then be obtained by combining these two properties via the silent existential-closure type-shifter E defined in (21), whose meaning is the same as the meaning of the determiner *a*: it states that the intersection of the two properties it combines with is not empty.

(21) **Existential raising:** $E =_{def} \lambda P_{\tau t} \lambda Q_{\tau t}.\ P \cap Q \neq \emptyset$

The idea of a silent determiner that lifts its restrictor into an existential quantifier over potentially plural individuals has a long tradition. Winter cites Link (1987), (Verkuyl, 1993, ch. 5), and (Carpenter, 1997, ch. 8) as his predecessors. As Winter discusses in detail, one can furthermore think of E as a simplified generalization of independently-needed choice-functional operators. The fact that choice-functional operators are generally taken to apply to nouns makes it a natural assumption to apply E to nouns as well, as I will do below. The use of E does not make the use of choice functions explicit since it essentially corresponds to a choice function that has narrowest possible scope. At this preliminary stage in the analysis, this does not matter, but as we progress we will replace E with an explicit choice function variable that will be bound at a higher place than it is introduced. Winter develops his own analysis in a similar way and talks abstractly about the *E/CF mechanism* (where CF stands for choice function). I will talk about E as long as I rely on the type-shifter in (21) but keep in mind that I will eventually replace it by choice functions.

Given these assumptions, Winter analyses the subject of sentence (19) as in (22), a property which is true of any set that contains the collective individual consisting of John and Mary. This gives the right truth conditions once it combines with the verb phrase, as shown here:

(22) $[\![\mathrm{E}(\min(\lambda P.P(\mathrm{john}) \cap \lambda P.P(\mathrm{mary})))]\!] = \lambda C_{\langle et,t\rangle}.\{j, m\} \in \mathrm{C}$

Turning now to noun-noun coordination, which Winter (2001) does not discuss, I assume that the coordination *man and woman* in (2b) involves the two silent operators just presented, but in a different order. Specifically, I assume that E may apply to nominal predicates without affecting their syntactic category. So it can apply to a nominal like *man* and return another nominal, which I assume it does here, on both sides of the conjunction. This is the part of the analysis that is motivated by the *Lawrence of Arabia* movie example in (7). The standard assumption is that coordination does not affect syntactic categories, so the result of coordinating E(man) with E(woman) is again a nominal. At this stage, the denotation of *man and woman* is the same as the denotation of the noun phrase *a man and a woman*, although their syntactic categories differ. The denotation results from intersecting the generalized quantifier $\lambda P.\exists x.\mathrm{man}(x) \wedge P(x)$ with the generalized quantifier $\lambda P.\exists x.\mathrm{woman}(x) \wedge P(x)$. The result is the following:

(23) $[\![\mathrm{E(man)\ and\ E(woman)}]\!] = \lambda P_{et} \exists x \exists y.\mathbf{man}(x) \wedge \mathbf{woman}(y) \wedge P(x) \wedge P(y)$

With Winter, I assume that a nominal predicate of type $\langle et, t\rangle$ must first be "distilled" before it can be used further, in this case as the restrictor of the (overt) determiner *a*. As in the previous case, this is achieved by the minimization operator. Conceptually, here as before, the input to this operator is a generalized quantifier over ordinary individuals, and its output is a predicate over collective individuals. In this case, assuming (as I will throughout the paper for convenience) that the set of men and the set of women are disjoint, the output is the predicate that holds of any man-woman pair:

(24) $[\![\text{min(E(man)} \cap \text{E(woman))}]\!] = \lambda P_{et}\exists x\exists y.\textbf{man}(x) \wedge \textbf{woman}(y) \wedge P = \{x, y\}$

From here on, I will abbreviate this collective predicate as **mw-pair**.

As mentioned, I model collective predicates as set predicates, so their type is $\langle et, t\rangle$. (Even though this happens to be the type of an ordinary generalized quantifier, the two are conceptually very different.) The next step is for the nominal *man and woman* to combine with the determiner. Ordinary determiners expect their restrictor and their nuclear scope to be of type $\langle et\rangle$. In order for determiners to combine with $\langle et, t\rangle$-type predicates instead, I assume following Winter that they are adjusted via the determiner fitter *dfit*, defined as follows:

(25) **Determiner fitter:** $\text{dfit} =_{def} \lambda D_{\langle et,\langle et,t\rangle\rangle}\lambda A_{\langle et,t\rangle}\lambda B_{\langle et,t\rangle}.D(\bigcup A)(\bigcup(A \cap B))$

Like the other silent operators in this system, this one is needed independently of concerns involving coordination. Winter motivates this operator by sentences like (26), in which the collective predicate *met* is an argument of a quantificational determiner.

(26) No students met.

One more operator needs to be introduced before we can see how determiner fitting works. Winter assumes that plural morpheme on *students* triggers the insertion of a "predicate distributivity" (*pdist*) operator. The function of *pdist* is similar to the well-known star and D operators in the literature on plurals and distributivity (e.g. Link (1983, 1991)). In addition, it also prepares ordinary $\langle et\rangle$-type predicates so they may combine with determiners that have been adjusted for $\langle et, t\rangle$-type predicates via determiner fitting. This is relevant, for example, when a fitted determiner combines with two predicates of which one is of type $\langle et, t\rangle$ and the other one is of type $\langle et\rangle$, as in *No students smiled.* The *pdist* operator is defined as follows:

(27) **Predicate distributivity:** $\text{pdist} =_{def} \lambda P_{et}\lambda P'_{et}.P' \neq \emptyset \wedge P' \subseteq P$

Using the operators (25) and (27), Winter analyzes sentence (26) in terms of the meanings of singular *no* and *student*. Its meaning is predicted to be "No student is a member of a set of students that met".

(28) $[\![\text{dfit(no)(pdist(student))(met)}]\!]$
$= [\![\text{no}]\!](\bigcup \text{pdist}([\![\text{student}]\!]))(\bigcup (\text{pdist}([\![\text{student}]\!]) \cap [\![\text{met}]\!]))$
$= [\![\text{no}]\!]([\![\text{student}]\!])(\bigcup \{P \in [\![\text{met}]\!] : P \subseteq [\![\text{student}]\!]\})$
$= \neg\exists x.\ [\textbf{student}(x) \wedge \exists P.\ x \in P \wedge P \in \textbf{meet} \wedge \forall y.y \in P \rightarrow \textbf{student}(y)]$

Given this, my LF for sentence (2b) is shown in (29).

(29) $[\![\text{dfit(a)(min(E(man) and E(woman))(meet\_in\_the\_park)}]\!]$
$= \textbf{a}(\bigcup \textbf{mw-pair})(\bigcup(\textbf{mw-pair} \cap \textbf{meet\_in\_the\_park}))$
$= \exists x.\exists y.\textbf{man}(x) \wedge \textbf{woman}(y) \wedge \textbf{meet\_in\_the\_park}(\{x, y\})$

This is true iff the verb phrase, the collective predicate *met in the park*, holds of at least one man-woman pair. To see this, observe that the first argument to **a** in (29) is the union of all man-woman pairs, that is, the set containing every person whatsoever (I assume for the sake of the example that every person is either a man or a woman). The second argument to **a** is the union of all those man-woman pairs that met in the park. This set will contain every person who met in the park with a member of the opposite sex. Now the denotation of **a** is just E as defined in (21), but with $\tau = e$. In other words, (29) will be true just in case there is a member of the first set (the set of all people) that is also a member of the second set (the set of people who met in the park with a member of the opposite sex). In other words, (29) is true just in case a man and a woman met in the park, as desired.

Of course, noun-noun coordination does not require the verb phrase to be collective. A sentence like (30a), with a distributive predicate in the verb phrase, is represented as in (30b). Here, *pdist* and *dfit* make sure that the property of smiling is distributed over the two elements of whatever man-woman pair the sentence is about.

(30) a. A man and woman smiled.
b. $[\![\text{dfit(a)(min(E(man) and E(woman))(pdist(smile))}]\!]$
$= \exists x.\exists y.\mathbf{man}(x) \wedge \mathbf{woman}(y) \wedge \{x, y\} \subseteq \mathbf{smile}$

The application of *dfit* in sentences involving the determiner *a* might seem like a roundabout way to get to the right truth conditions. In the case of *a*, one could just as well have set $\mathbf{a} = E$, without the restriction $\tau = e$, so that there would be no type mismatch and *dfit* would not be required. To see this, assume that NP and VP are two sets of sets. Now $\mathbf{a}(\text{NP}, \text{VP})$ is true by definition iff $\text{NP} \cap \text{VP}$ is nonempty, and $\text{dfit}(\mathbf{a})(\text{NP}, \text{VP})$ is true iff $(\bigcup \text{NP}) \cap (\bigcup(\text{NP} \cap \text{VP}))$ is nonempty. The latter term is equivalent to $\bigcup(\text{NP} \cap \text{VP})$, and this set is empty just in case $\text{NP} \cap \text{VP}$ is either empty or it only contains the empty set. But typically, VP will not contain the empty set since it is either a set predicate, in which case its elements represent collective individuals and are therefore nonempty sets, or it is derived via *pdist*, in which case the empty set is excluded by definition. So typically, $\mathbf{a}(\text{NP}, \text{VP})$ is true iff $\text{dfit}(\mathbf{a})(\text{NP}, \text{VP})$ is true, and an analogous argument can be made for the case of *no*.

As far as *a* and *no* are concerned, then, we might allow both kinds of derivations – the one without *dfit* and the one with it – to coexist without harm or we might use only the first kind and drop *dfit* from the system. But this will not do for sentences with nonintersective determiners and collective predicates, such as the following:

(31) Every knife and fork matches in style. (Heycock and Zamparelli, 2005)

At least for some speakers, this sentence has a reading that requires every knife to match with some fork and every fork to match with some knife, but leaves it open whether there is matching across all pieces of silverwear whatsoever. There is perhaps also another, stronger reading that requires the latter, i.e. every knife to match with every fork and every fork to match with every knife. The first reading is generated by the derivation with *dfit* and the second reading by the derivation without *dfit*. Thus we need *dfit*. To see this, observe that *knife and fork*, after minimization, denotes the set of all knife-fork pairs. If there are three knives and three forks and nothing else, then there will be nine such pairs. The derivation with *dfit* will give *every* as its first argument the set containing all six pieces of silverwear, and as its second argument the set containing every knife that matches a fork and every fork that matches a knife. This correctly derives the desired truth conditions.

Even in this case one might wonder if these truth conditions are correct, and thus if *dfit* is really needed. Sentence (31) perhaps does not require every fork to match merely with *some* knife but rather with the knife that is saliently paired with it – such as the knife at the same seat on the dinner table. This saliency effect is not captured by either analysis, and since it is context dependent, it could be taken to be a sign of contextual domain restriction of the universal quantifier. This might also be required in case (31) requires the number of knives to be equal to the number of forks, something which is not captured on the present analysis. If a contextual restriction turns out to be needed, then perhaps the appeal to Winter's *dfit* becomes superfluous again as far as noun-noun coordination is concerned. In Section 6 we will encounter yet another use of *dfit*, one that is related to disjunction rather than conjunction.

3 Lawyers, doctors, and other overlappers

In the previous section, I have chosen the two nouns *man* and *woman* to illustrate the basic framework because they denote disjoint sets (hermaphrodites aside) and this made it easier to present the system. Let us now take a closer look at what happens when the two nouns denote overlapping or even identical sets. First consider the case of merely overlapping sets. Assume for example that some but not all doctors are lawyers, and not all lawyers are doctors. Assume for simplicity that these are the only two professions that exist. Consider now the following sentence:

(32) A doctor and lawyer met.

Sentence (32) is true iff some individual who is a doctor met a distinct individual who is a lawyer. This does not preclude, say, the first individual from being both a doctor and a lawyer. The derivations we have seen so far are couched in an extensional setting and don't predict this. Applying the minimizer (20) to E(doctor) and E(lawyer) returns the set of all sets S with the following three properties: (i) S contains a doctor d; (ii) S contains a lawyer (who may or may not be distinct from d); and (iii) has no proper subset that contains a lawyer and a doctor. Condition (iii) is the contribution of the minimizer, and its effect in this case is that there will be two different kinds of sets S: singleton sets containing a doctor-lawyer, and two-element sets that contain a single-profession doctor and a single-profession lawyer. This is a problem, since it predicts that the truth (32) requires each of the two individuals to belong to only one profession. In the extreme case where the two professions coincide, we have $[\![\text{doctor}]\!] = [\![\text{lawyer}]\!]$ due to the extensional setting, and the minimizer returns a set of singletons. This is even worse, because (32) is now predicted to be deviant for the same reason that (33) is: a single individual cannot meet itself.

(33) #John met.

Winter (2001) discusses a similar potential pitfall for his own approach, on which the present one is based. Assume that John is a man and that *some man* is modeled as a generalized quantifier in the style of Barwise and Cooper (1981). Then sentence (34) is predicted to be deviant for the same reason as (33) is, since the smallest set that contains John and some man is the singleton set of John, and the minimizer eliminates all other sets from the denotation of the conjoined noun phrase.

(34) John and some man met.

One could think of different ways to solve this puzzle. For example, one could exploit the fact that indefinites generally come with a novelty condition (Heim, 1982). This novelty condition is particularly strong when two indefinites are conjoined. Thus the following sentence cannot be true merely in virtue of a single male student who smiled:

(35) A man and a student smiled.

An implementation of this novelty condition could proceed by enriching the system with a dynamic component. I will take another route, however, which involves the use of choice functions, following Winter (2001). A choice function is a function that maps any nonempty set to one of its elements. My adoption of Winter's solution is in part due to pragmatic purposes (it is easier to import one framework wholesale than to merge two of them) and in part due to the fact that Winter argues for two choice function operators, a nondistributive and a distributive one. Each one of them will play an important role in the following development. The nondistributive choice-functional operator will be used to solve the problem of overlap. In the next section, the distributive one will be used to generate the "five-people" reading mentioned in the introduction.

Winter's solution to this puzzle is to assume that *some man* is not, in fact, a generalized quantifier. He assumes instead that indefinite determiners like *some* involve a variable whose value is a choice function. The account is similar to classical choice-functional accounts of indefinites like (Reinhart, 1997). This choice function applies to the complement of *some*. For example, in (34), the set of men is mapped to a man. Winter then assumes that this man is Montague-lifted in order for *and* to be intersective. Thus for Winter, indefinites are hybrids of a generalized quantifier and a choice function variable. To interpret (34), then, we pick a man, Montague-lift him to his generalized quantifier, intersect it with the Montague lift of John, send the result through the minimizer, and finally existentially quantify over how we picked him by binding the choice-function variable. Conceptually, Winter splits E into two components: a choice function variable that applies to the complement, and a silent operator that binds that variable by an existential quantifier higher up in the tree.

Here is a simple implementation of Winter's two-component idea in the well-known framework of Heim and Kratzer (1998). (Winter himself uses variable-free semantics in the style of Jacobson (1999), but this choice is not essential.) Assume that every occurrence of the determiner *some* is indexed with a distinct natural number. For a given occurrence $some_i$ assume that g is a variable assignment which maps the index i to a choice function of type et, e. We define the interpretation of $some_i$, written $[\![\text{some}_i]\!]^g$, as follows:

(36) $[\![\text{some}_i]\!]^g = \lambda N_{\langle et \rangle} : N \neq \emptyset . \lambda P_{\langle et \rangle} . P(g(i)(N))$

In words, the interpretation of $some_i$ given a variable assignment g maps i to a (partial) function that expects a set of individuals N (a singular noun), and is defined whenever that set is nonempty. When defined, that function asks the variable assignment g for the value of i, which is assumed to be a choice function, then lets that choice function choose an individual from the set N and finally returns that individual's Montague lift, that is, the set of all properties P which hold of that individual. For example, g might map i to the choice function that maps any set to the tallest individual in that set, and N might be the set containing Laurel (175cm) and Hardy (185cm). In that case $[\![some_i]\!]^g$ applied to N would return the set of all properties that Hardy has. This is the first component.

The second component introduces the existential quantifier that binds the operator just defined. I will write $\exists$ for it. I assume that whenever $\exists$ is inserted into the LF tree, an index node of type $\langle et, e\rangle$ is inserted right underneath it and is interpreted via the predicate abstraction rule in (37). For more details on the rule and on this strategy, see (Heim and Kratzer, 1998). I will represent this index node as an indexed λ symbol.

(37) **Predicate abstraction:** $[\![[\lambda_i\ \alpha]]\!]^g = \lambda f.[\![\alpha]\!]^{g[i\to f]}$

The $\exists$ operator corresponds to the variable-free operator Winter calls "existential choice closure", and it is defined as follows:

(38) $[\![\exists]\!]^g = \lambda A_{\langle\langle et,e\rangle,\langle\alpha_1\ldots\alpha_n t\rangle\rangle}\lambda P_{\alpha_1}\ldots\lambda P_{\alpha_n}\exists f.\mathrm{CF}(f)\wedge A(f)(P_1)\ldots(P_n)$

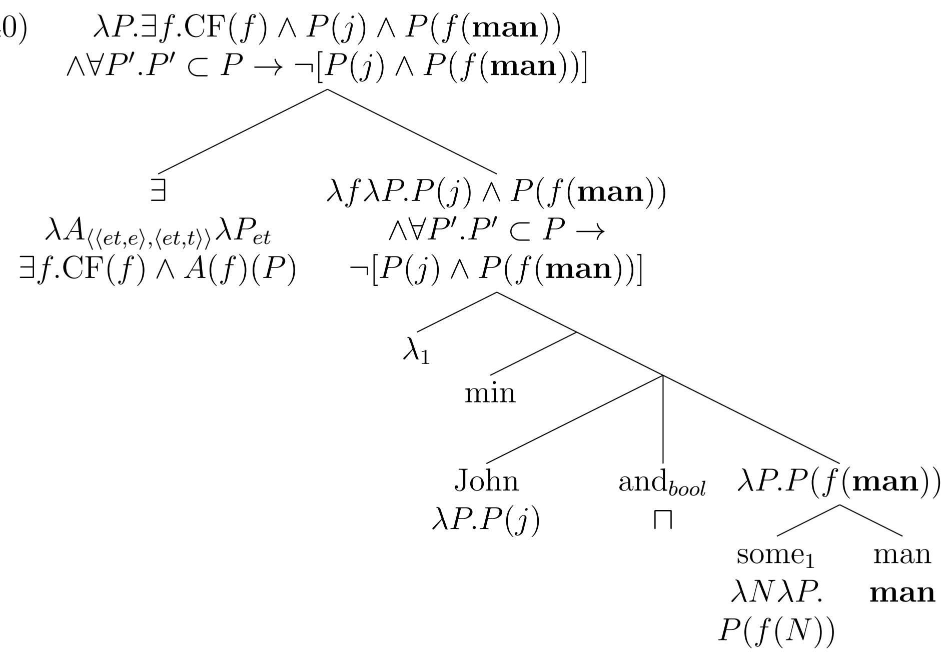
Here, CF stands for the predicate that holds of any function f of type $\langle et, e\rangle$ iff it is a choice function, that is, iff for any nonempty set N of type et, we have $f(N)\in N$. The number n stands for the arity of the predicate to which predicate abstraction applies. In the case we are interested in, namely quantificational noun phrases like *John and some man*, we have $n = 1$ since they only expect one predicate (the verb phrase) and it is of type $\langle et\rangle$. In that case, (39) simplifies as follows:

(39) $[\![\exists]\!]^g = \lambda A_{\langle\langle et,e\rangle,\langle et,t\rangle\rangle}\lambda P_{et}\exists f.\mathrm{CF}(f)\wedge A(f)(P)$

When (36) occurs in the immediate scope of the predicate abstraction of (39), the net effect is the same as the existential raising operator E in (21). The extra power comes from the possibility of having $\exists$ take nonlocal scope. This is motivated from the literature on choice functions. Indeed, the ability of indefinites to take nonlocal scope was the original motivation for their analysis in terms of choice functions (Reinhart, 1997).

This tree for the noun phrase of sentence (34), shown below, conveys the idea. I have omitted the definedness condition $N \neq \emptyset$ to avoid cluttering the tree.

(40)



The term at the root of the tree denotes the set of all properties P such that there is a way of choosing a man such that P holds of John, of that man, and of nothing else. Given that John is a man, any such property will either be the singleton of John or it will be a set of two men one of which is John. The restriction to nonempty sets is inherited from Winter's treatment of choice functions and is independently motivated (Winter, 2001).

It is vacuous in this example given that John is a man, but it will do real work in other cases. For example, the restriction will make sure that *man and woman* fails to denote anything in all-male or all-female models.

We can represent the term at the root of the tree in (40) equivalently as follows:

(41) $[\![[\exists\ [\lambda_1[\ \text{min [John} \sqcap \text{[some}_1\ \text{man]]]]]}]\!] = \lambda P \exists x \in \mathbf{man}.P = \{j\} \cup \{x\}$

If there are exactly three men, namely John, Bill, and Sam, this term will denote the set

(42) $\{\{j\}, \{j, b\}, \{j, s\}\}$

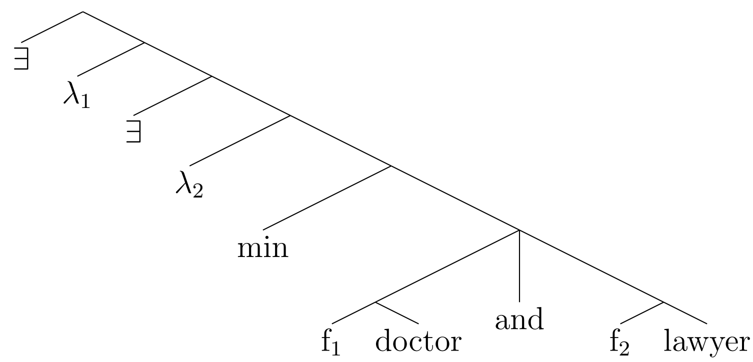
Now this term can be prepared for combination with a verb phrase such as *met* by an application of the existential raising operator E, as in the analysis of *John and Mary met*, whose noun phrase is shown in (22). In the same model as above, this results in

(43) $[\![[\text{E}[\exists[\lambda_1[\ \text{min [John} \sqcap \text{[some}_1\ \text{man]]]]]]}]\!] = \lambda C_{\langle et,t \rangle}.\exists P \in \{\{j\}, \{j, b\}, \{j, s\}\} \cap C$

which is the truth condition we desire. Thus there are two applications of the E/CF mechanism in Winter's analysis of *John and some man met*: one is responsible for the analysis of *some* in the subject, and the other one is responsible for combining the subject with the verb phrase. This concludes the presentation of Winter's two-component idea.

In procedural terms, by giving the existential quantifier over the choice function wide scope, Winter allows us to delay the choosing of a man until after we have minimized the set of sets containing John and that man. I propose to use the same trick to the analysis of doctor/lawyer sentences. We assume that a silent indefinite applies to each of the nouns and delays the choosing of a doctor and the choosing of a lawyer until after minimization has applied. For this purpose, we introduce silent and uniquely indexed indefinites f_i whose meaning is the same as that of the overt indefinite *some*$_i$ defined in (36), and which are found in adjectival position, just next to the nouns they apply to. This corresponds to the step which we have motivated above by the existence of constructions like *this one film*. Given this, the LF for the nominal *doctor and lawyer* in (32) is as follows:

(44)



And it evaluates as follows:

(45) $[\![(44)]\!] = \lambda P_{et} \exists x \exists y.\mathbf{doctor}(x) \wedge \mathbf{lawyer}(y) \wedge P = \{x\} \cup \{y\}$

This is the set of all sets that contain a doctor, a lawyer, and nobody else. The two do not have to be distinct, but they may be. So if there are doctor-lawyers in the model, then among these sets there will singleton sets containing them. But there will also be two-membered sets containing a doctor and a lawyer, even if they happen to share one or both of their professions. We obtain the denotation of (32) by applying determiner fitting to *a* and using the result to combine (45) with **met**, in a way analogous to the analysis of *A man and woman met in the park* in (29). With **dl-set** abbreviating the predicate in (45), the resulting truth conditions are as follows:

(46) $\mathbf{a}(\bigcup \mathbf{dl\text{-}set})(\bigcup(\mathbf{dl\text{-}set} \cap \mathbf{meet}))$
$= \exists x.\exists y.\mathbf{doctor}(x) \wedge \mathbf{lawyer}(y) \wedge \mathbf{meet}(\{x\} \cup \{y\})$

This is true just in case a doctor and a lawyer met, regardless of whether they share any professions. The two-component solution makes it possible for them to be distinct individuals, and world knowledge about meetings requires it.

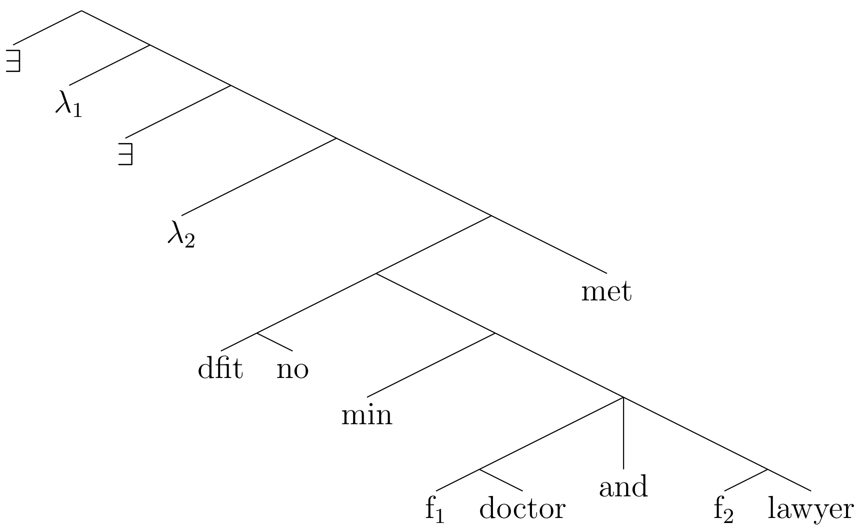
Whenever we have an operator that can take nonlocal scope, there is question as to how wide its scope can be. It is immediately apparent that it would not do to allow the choice function closure operator to go too high. The following two examples are attested, and the oddity of the suggested paraphrases makes it clear why the scope-taking abilities of ∃ need to be reined in.

(47) a. A set of pairings is called stable if under it there is no man and woman who would both prefer each other to their actual partners.[4]
b. #There are a man and a woman such that a set of pairings is called stable if under it they would not both prefer each other to their actual partners.

(48) a. No matter how much they desire children, no man and woman have a right to bring into the world those who are to suffer from mental or physical affliction.[5]
b. #There are a man and a woman who do not have a right to bring into the world those who are to suffer from affliction.

The problem in (47b) and (48b) seems to be that the choice function closure has taken scope out of a non-upward-entailing context, namely the restrictor of *no*. That is, configurations like the following do not seem to be allowed:

(49)



[4] www.usc.edu/programs/cerpp/docs/Two-SidedMatching.docx

[5] http://www.nyu.edu/projects/sanger/webedition/app/documents/show.php?sangerDoc=237888.xml

A brute-force fix that rules out these configurations consists in stipulating that ∃ must occur immediately above *min*. I have no explanation for the fact that choice function closure does this. To some extent, this is perhaps a reflection of the fact that existential quantifiers over choice functions may in general need to be reined in. See the relevant discussion for in Schwarz (2001, 2004) for Skolemized choice functions, which as he shows, cannot straightforwardly take scope above a non-upward-entailing operator – see also Schlenker (2006). Skolemized choice functions are essentially choice functions with one or more additional arguments that influences their choice. For example,

(50) No woman read some book I recommended.

does not have a reading that could be paraphrased as:

(51) There is a Skolemized choice function f such that no woman read that book I recommended which f assigns to her.

This missing reading could also be paraphrased as "There is a way to assign books I recommended to women such that no woman read the book mmmassigned to her", which is another way to say "No woman read every book I recommended". This reading is clearly unavailable. An analogous phenomenon occurs in connection with indefinites that contain syntactic bound variables, such as bound pronouns, as Schwarz discusses:

(52) No woman read some book I recommended to her.

This sentence uses a bound pronoun to make the dependency between women and books explicit, and it does not have the missing reading paraphrased above any more than sentence (50) does.

In the face of this problem, several reactions seem plausible. One is to give up the idea that choice functions are a plausible model of the semantics of indefinites (Heim, 2011). Another one is to hold on to choice functions but introduce constraints on the scope of the existential quantifiers that bind them, as is suggested here. These constraints would be different from the familiar island constraints on universal quantifiers. The obvious question is whether such constraints can be plausibly motivated. The fact that choice function binders must be constrained both in the case of indefinites and in the case of coordination can be seen either in a pessimistic light, given that choice functions were originally motivated by the need to give indefinites a way to escape island constraints, or in a more optimistic light, given that the need to constrain them seems independent in the two cases and therefore one of the two cases may be seen as providing motivation for the other.

4 How many people are ten men and women?

As discussed at the end of Section 1, collectively interpreted conjunctions of plural nouns are in principle ambiguous as to the number of entities involved. So *five men and women* can involve reference to a total of ten people, with five men and five women among them, or (more likely) to a total of five people, with some men and some women among them. I have mentioned there that (only) the first reading is predicted by accounts of noun-noun coordination that give *and* an intersective denotation and appeal to determiner deletion or to its semantic equivalent (Cooper, 1979). On Cooper's account applied to plurals, *five men and women* would denote the set of all properties P such that five men have P and five women have P. This could be combined with the verb phrase without further ado if that verb phrase denotes a distributive predicate, and it may work with additional assumptions if the verb phrase is collective, as in the title of the paper (*ten men and women got married today*). But it is the second reading – a total of five people – whose existence shows that determiner deletion will not do in general, so it requires a new approach.

For sets P and Q, define a *P/Q-mixture* as any union of a nonempty $P' \subseteq P$ with a nonempty $Q' \subseteq Q$. So a man/woman-mixture is a set containing at least one man, at least one woman, and nothing which is neither a man nor a woman. Given this, we can represent as follows the meaning of *five men and women* that we want to derive:

(53) $[\![\text{five men and women}]\!] = \{P_{et} : |P| = 5 \wedge \text{P is a man/woman-mixture }\}$

I assume that numerals have the same type as intersective adjectives and are combined with pluralized nouns (or nominals) by predicate modification, that is, intersection (Verkuyl, 1981, e.g.). For an overview of these theories, see (Landman, 2004, ch. 1). So for example, *five* denotes the set of all those sets that contain exactly five individuals. The system I assume is equally compatible with a theory on which they have the same type as nonintersective adjectives but otherwise the same semantics as intersective adjectives, and combine with nouns by function application. One such theory is Winter (2001). Since the adjectival theory of numerals is widely adopted in the literature and since in particular Winter adopts it, I will do so too.

Here is my entry for the numeral *five*:

(54) $[\![\text{five}]\!] = \{P_{et} : |P| = 5\}$

This set is intersected with the plural noun, which in turn is analyzed as being derived from the singular noun the *pdist* operator defined in *pdist*, following Winter (2001). The result of the intersection is shown in (56).

(55) $[\![\text{men}]\!] = [\![\text{pdist(man)}]\!] = \{P_{et} : P \neq \emptyset \wedge P \subseteq \textbf{man}\} = \wp(\textbf{man})\backslash\emptyset$

(56) $[\![\text{five men}]\!] = \{P_{et} : |P| = 5 \wedge P \neq \emptyset \wedge P \subseteq \textbf{man}\}$

The question now is how to derive a predicate *men and women* that intersects with *five* in the desired way, analogously to the way *men* intersects with *five*. We cannot apply the E/CF mechanism to produce the set of all man/woman mixtures that we need in order to derive (53). For example, if we ignore the contribution of the plural morpheme for a moment, the E/CF mechanism amounts to picking a man and a woman, and minimizing the intersection of their Montague lifts. This gives us the set of all man-woman pairs, but pairs are too small to be in the denotation of *five*. An example of this derivation that uses E is shown in (57a).

(57) a. $(\text{min}(\text{E(man)} \sqcap \text{E(woman)})) = \{\{x, y\} : \textbf{man}(x) \wedge \textbf{woman}(y)\}$
b. $[\![\text{five}]\!] \cap (57\text{a}) = \emptyset$

The same problem obtains if we apply the plural morpheme to the two nouns before E applies to them. This time, *men and women* denotes the set of all pairs of a set of men and a set of women. Again, pairs are too small to be in the denotation of *five*, since the cardinality of a pair is always two.

(58) a. $(\text{min}(\text{E(pdist(man))} \sqcap \text{E(pdist(woman))}))$

$= \{\{M, W\} : M \neq \emptyset \wedge M \subseteq \textbf{man} \wedge W \neq \emptyset \wedge W \subseteq \textbf{woman}\}$

b. $[\![\text{five}]\!] \cap (58a) = \emptyset$

At this point we might consider giving up the theory that the semantics of numerals is intersective. This is doable, and it is even independently supported by languages like Hungarian and Turkish where numerals combine with morphologically singular nouns and can therefore not be intersective. But in English, there is no independent support for it, and so I will follow another path that does have independent support.

My proposal is to use a distributive generalization of choice functions variables that is used and motivated for reasons independent of noun-noun coordination (Winter, 2001). Based on earlier work by Eddy Ruys, Winter observes that the existential component and the distributivity component of numeral indefinites can have two distinct scopes. Sentence (59) has a reading that does not involve three specific workers and a reading that does. These readings are paraphrased in (59a) and in (59b) respectively.

(59) If three workers in our staff have a baby soon, we will have to face some hard organizational problems.

a. If any three workers each have a baby, there will be problems. if $> 3 > D > 1$

b. There are three workers such that if each of them has a baby, there will be problems. $3 >$ if $> D > 1$

In the latter reading, the existential component of *three workers* takes scope outside of the antecedent of *if*, but the distributive component takes scope inside of it. Since antecedents of *if*-clauses are islands for quantifiers, this illustrates that the existential component of *three workers* is not island-bound, a fact that is familiar from the literature on choice functions. Unlike the existential component, however, the distributive component cannot take scope outside of the *if*-island. If it could, sentence (59) should have a reading that can be paraphrased as follows, contrary to fact:

(60) There are three workers such that for each x of them, if x has a baby, there will be problems. $^*3 > D >$ if > 1

To model this behavior, I assume following Winter that we need to split up existential raising as before into $\exists$ and a generalized quantifier over a choice function variable, and that the former but not the latter is able to escape islands. This time, unlike in the singular case, the generalized quantifier will now be distributive on its second argument. This is because in the singular case, a choice function applies to a set of men to pick one of these men, and then the appropriate generalized quantifier over that choice function returns the set of all properties that this man has. In the plural case, a choice function applies to a set of sets of men to pick one of these sets of men, and then the appropriate generalized quantifier over that choice function returns the set of all properties P such that each of these men has P. So we need two E/CF mechanisms, a nondistributive one for singular indefinites and a distributive one for plural indefinites. Loosely following Winter, I will write the lower component of the nondistributive one as f, and the lower half of the distributive one as f^d. The f^d operator is not confined to indefinites; it is a variant of the D operator known from the literature on distributivity that is used to model the (prominent) distributive reading of sentences like *The girls are wearing a dress* (Link, 1991). Indeed, the f^d operator can be used to model this reading and can therefore potentially replace the D operator (Winter, 2001, p. 156). I repeat the definition of f

from (36) for comparison in (61), and I give the definition of f^d in (62).

(61) $[\![f_i]\!]^g = \lambda N_{\langle et \rangle} : N \neq \emptyset . \lambda P_{\langle et \rangle} . P(g(i)(N))$

(62) $[\![f_i^d]\!]^g = \lambda N_{\langle et,t \rangle} : N \neq \emptyset . \lambda P_{\langle et,t \rangle} . g(i)(N) \subseteq P$

To illustrate the way in which Winter uses f^d to analyze reading (59b) of sentence (59), here is his representation of that reading:

(63) $\exists f.\mathrm{CF}(f) \wedge [[f^d(\mathbf{three}(\wp(\mathbf{worker})\backslash\emptyset))(\lambda x.\exists y(\mathbf{baby}(y) \wedge \mathbf{have}(y)(x)))] \rightarrow \mathbf{problems}]$

The important things to notice about this formula are the following. The component $f^d(\mathbf{three}(\wp(\mathbf{worker})$ denotes the set of all those properties that hold of each of the three workers picked by the choice function in question. The component $\exists f.\mathrm{CF}(f)$ existentially quantifies over choice functions. The former component is in the scope of the implication arrow, while the latter component takes scope over it. This is exactly the configuration we need for reading (59b). The lower component involves f^d rather than f. This is needed in order to distribute the property of having a baby down to each of the three workers. If f was used instead, a nonsensical reading would be generated in which the property of having a baby is attributed to the three workers collectively.

We have seen that f^d is independently motivated. Given that it is used on plural nouns where f is used on singular nouns, the natural assumption is that *men and women* has the same structure as *man and woman* except that f^d is used in the former where f is used in the latter. The following derivation shows that this leads to the right predictions:

(64) $[\![f_1^d]\!] = \lambda N_{\langle et,t \rangle} : N \neq \emptyset . \lambda P. f(N) \subseteq P$

(65) $[\![f_1^d(\text{men})]\!] = \lambda P.\ f_1(\wp(\mathbf{man})\backslash\emptyset) \subseteq P$

(66) $[\![f_2^d(\text{women})]\!] = \lambda P.\ f_2(\wp(\mathbf{woman})\backslash\emptyset) \subseteq P$

(67) $[\![f_1^d(\text{men}) \sqcap f_2^d(\text{women})]\!] = \lambda P.\ f_1(\wp(\mathbf{man})\backslash\emptyset) \subseteq P\ \wedge\ f_2(\wp(\mathbf{woman})\backslash\emptyset) \subseteq P$

(68) $[\![\min(f_1^d(\text{men}) \sqcap f_2^d(\text{women}))]\!] = \lambda P.\ P = f_1(\wp(\mathbf{man})\backslash\emptyset)\ \cup\ f_2(\wp(\mathbf{woman})\backslash\emptyset)$

(69) $[\![\exists(\exists(\min(f_1^d(\text{men}) \sqcap f_2^d(\text{women}))))]\!] = \{P\ :\ P \text{ is a man-woman mixture }\}$

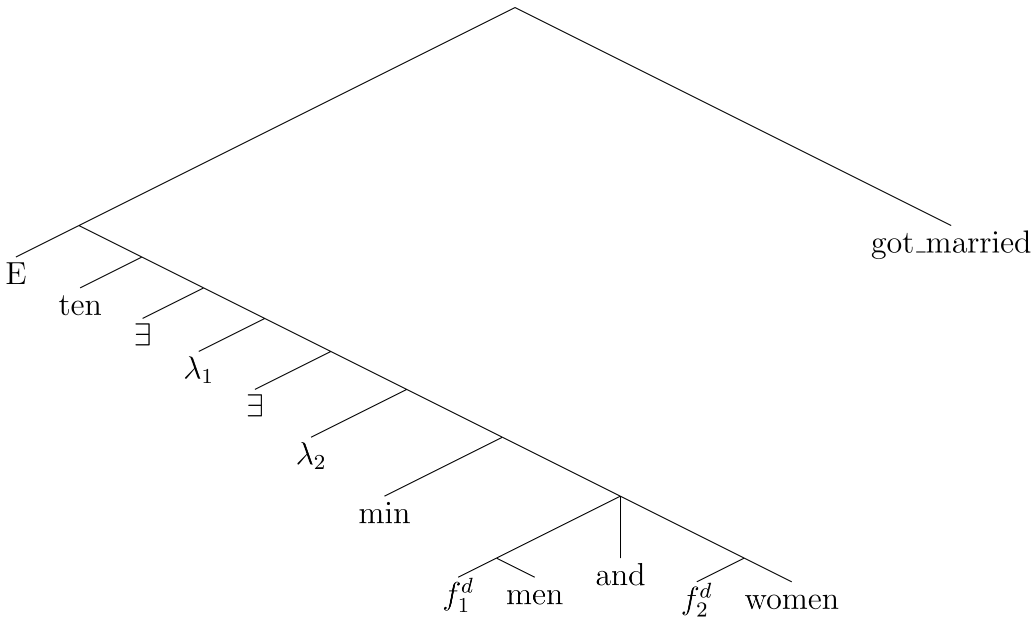
In procedural terms, this is what happens. We start with the set denoted by the plural noun *men*. This is the set of all nonempty sets of men. We choose one of these sets of men and place a hold on our choice. We create the set of all those properties that hold of each of these men, that is, we create all supersets of the set of men that we chose. We do the same thing for a similarly chosen set of women. We intersect and minimize the two sets of properties. Given our fixed choice of men and our fixed choice of women, the only element that is left over by minimization is the set that contains exactly the men and the women we picked. We now release the hold on our choice of men and the hold on our choice of women. This gives us more elements: the set of all properties P such that there is a way of picking some men and some women that gives us all and only the people of which P holds. In other words, we get the set of all man-woman mixtures. This use of the f^d operator to derive collective readings of plural noun-noun coordinations is independently motivated by its use in the analysis of noun phrase coordinations in sentences like (70) by Winter (2001):

(70) a. Two Americans and three Russians made an excellent basketball team.
b. These women are the authors and the teachers.

Winter's analysis of this type of example proceeds in a similar way as the present one. For example, in (70a), a distributive choice function operator is used to pick two Americans and return the set of all those properties that hold of each of them. Another operator is used to pick three Russians and return the set of all those properties that hold of each of them. The result is intersected and minimized, and the choice function variables introduced by the operators are existentially bound later. In (70b), the choice function mechanism operates in a similar way. Winter assumes that the definite noun phrases are predicative, so that *the authors* returns the property of being the set of all the authors. The choice function operators are still existentially bound and therefore indefinite in a sense, but that indefiniteness is masked by the presupposition of the definite determiner. Winter's suggestion that there are hidden indefinite components even in the meaning of definite noun phrases is similar to the claim defended in this paper, as discussed in section 1 in connection with the *this one film* example.

The next steps in our derivation are the same as in *Ten men met*, and in example (70). The set of man-woman mixtures is ready to be intersected with the numeral, be it *five* or *ten*. The result is the set of all man-woman mixtures of cardinality ten. We use existential closure to combine numeral noun phrases with verb phrases. We may choose to apply *pdist* to the verb phrase *get married* in order to get it to apply to pluralities even when more than one marriage is involved. Alternatively, since *get married* is a lexical predicate, we may assume that its meaning is closed under powerset formation already in the lexicon. The LF of the title of this paper, *Ten men and women got married today*, can then be given as follows.

(71)



5 Comparison to previous work

Like any system that adopts a uniform meaning for *and*, this one avoids redundancy of lexical entries. This improves the ambiguity theory, that is, on the view that some instances of *and* are intersective and others are collective (Link, 1984; Hoeksema, 1988). Since the meaning I adopt is intersective, it generalizes without problems to sentential coordination, verb-phrase coordination, and noun phrase coordination (Gazdar, 1980). This improves on the implementation of the collective theory in Heycock and Zamparelli

(2005), one of the few journal-length treatments of the semantics of noun-noun coordination. Noun-noun coordination is discussed in Winter (1995) and Winter (1998) though not in Winter (2001). The present system is vastly different from the treatment of noun-noun coordination in Winter (1998). In this section, I discuss Heycock and Zamparelli (2005) and Winter (1998) in more detail.

I highlight Heycock and Zamparelli (2005) because they are the most fully worked-out example of the collective theory of coordination. For example, Krifka (1990) also adopts the collective theory of coordination and shows how to generalize it to various cases such as adjectives and relational nouns, but he does not say much about the semantics of noun-noun coordination. He only specifies sufficient but not necessary truth conditions for conjoined expressions. According to him, *cat and dog* will apply among other things to all sums of a cat and a dog, and "some pragmatic strengthening" tells us to remove those other things from consideration. His account does not specify when the pragmatic strengthening occurs, and does not generate the intersective interpretation. For a thorough technical discussion and criticism of the accounts by Hoeksema (1988) and Krifka (1990) from the perspective of the intersective theory, see Winter (1998) and Winter (2001).

5.1 The collective theory: Heycock and Zamparelli (2005)

Heycock and Zamparelli (2005) adopt a collective entry for *and* that is equivalent to the one in (72). Essentially, this entry combines two sets of sets by computing their cross-product, except that instead of putting any two elements together to form a pair, it forms their union. Heycock and Zamparelli (2005) call this operation *set product* in reminiscence of the notion of cross-product. This treatment is somewhat similar to the systems for exact verification in van Fraassen (1969) and in recent unpublished work by Kit Fine. The connection between these works, and the question whether my criticism of Heycock and Zamparelli extends to those systems, is interesting but I will not pursue it here. The entry in (72) is assumed to be the one and only meaning for *and* in Heycock and Zamparelli (2005).

(72) $[\![\text{and}_{coll}]\!] = \lambda Q_{\langle \tau t,t\rangle} \lambda Q'_{\langle \tau t,t\rangle} \lambda P_{\tau t} \exists A_{\tau t} \exists B_{\tau t}.\ A \in Q \wedge B \in Q' \wedge P = A \cup B$

Heycock and Zamparelli (2005) assume that nouns and verb phrases denote sets of singletons. For example, the noun *man* denotes the set of all singletons of men, $\lambda P.|P| = 1 \wedge P \subseteq \textbf{man}$. When the nouns *man* and *woman* are conjoined, the entry in (72) generates the following denotation:

(73) $[\![\text{man and}_{coll}\text{ woman}]\!]$
$= \lambda P_{et} \exists A_{et} \exists B_{et}.\ |A| = 1 \wedge A \subseteq \textbf{man} \wedge |B| = 1 \wedge B \subseteq \textbf{woman} \wedge P = A \cup B$
$= \lambda P_{et} \exists x \exists y.\ \textbf{man}(x) \wedge \textbf{woman}(y) \wedge P = \{x, y\}$

This denotation is equivalent to the one my system generates, as seen in (24). In this respect, my system can be seen as a reconstruction of the one in Heycock and Zamparelli (2005) from first principles. But there is an important difference. I assume that all instances of *and* are intersective while Heycock and Zamparelli assume that all instances of *and* have the collective denotation in (72). The latter assumption leads to problems when quantifiers are conjoined that are not upward entailing, as in the following cases:

(74) a. No man and no woman smiled.

b. Mary and nobody else smiled.

Assume first, as Heycock and Zamparelli do, that the simplex noun phrases are treated as generalized quantifiers, as shown in (75) for *no man* (the unusual types are due to the assumption that nouns denote sets of singletons):

(75) $[\![\text{no man}]\!] = \lambda Q_{\langle et,t\rangle}.\neg\exists X_{\langle et\rangle}.[\![\text{man}]\!](X) \wedge Q(X)$

Heycock and Zamparelli predict that the complex noun phrase in (74a) holds of the union of any set **A** containing no man and any set **B** containing no woman. As **A** may contain women and **B** may contain men, the resulting truth conditions are too weak. For example, (74a) is true in a model that contains a smiling man called John, a smiling woman called Mary, and no other smilers. This is for the following reason. The entry for *no man* in (75) holds of the set containing nothing but the singleton of Mary, since that set contains no man; the corresponding entry for *no woman* holds of the set containing nothing but the singleton of John since that set contains no woman. According to entry (72), the noun phrase in (74a) therefore holds of the union of these two sets, namely, the set containing nothing but the singletons of John and of Mary. But this set is precisely the denotation of *smiled* in this model. For analogous reasons, (74b) is predicted to be true in this model (assuming that *nobody else* in this context means *nobody other than Mary*).

Heycock and Zamparelli are aware of this problem and suggest that scope-splitting analyses of *nobody*, as proposed by Ladusaw (1992) and others for languages with negative concord, might help here. On these analyses, the lexical entry of *no* is separated into one part that contains only $\neg$ and another part that contains everything else including $\exists x$, and the negation part is free to take scope in a higher position than the rest. But adopting such an approach would wrongly predict that (74b) means the same as *It's not the case that Mary and someone else smiled.* That sentence, unlike (74b), is true when Mary didn't smile but someone other than Mary smiled.

Coordination of non-upward-entailing quantifiers such as *no man and no woman* is a hard nut to crack for the collective theory. Not only do Heycock and Zamparelli (2005) not give a satisfying account of these conjunctions, it also does not seem easy to extend the collective theory under any implementation, unless one is willing to radically rethink the meaning of quantified noun phrases. I will not do that in this paper.

5.2 Departing from the intersective theory: Winter (1995, 1998)

In contrast to Winter (2001) discussed above, earlier work including Winter (1995) and Winter (1998, ch. 8) discusses noun-noun coordination, which is taken to require a departure from the intersective theory. This approach has been recently revived by Szabolcsi (2013) for the crosslinguistic analysis of certain particles like Japanese *mo*, which seem to be licensed by the presence of a covert conjunction or related notion. For Winter (1995) and Winter (1998, ch. 8), *and* always returns the denotations of its two conjuncts as an ordered pair. For example, *man and woman* is translated as the ordered pair in (76).

(76) $[\![\text{man and woman}]\!] = \langle \lambda x.\mathbf{man}(x), \lambda x.\mathbf{woman}(x)\rangle$

When such a pair combines with other items in the tree, it is first propagated upwards in a style reminiscent of alternative semantics (e.g., Rooth, 1985), in the sense that each of the two computations proceeds in parallel with the other. At any point in the derivation, this ordered pair can be collapsed back into a single denotation by covert application of $\sqcap$ as defined in (17). When this operation happens immediately, it mimics the behavior of intersective *and*; the reason for introducing it is to give *and* the possibility to take arbitrarily wide scope. As Winter (1998) demonstrates, this leads to the right results in cases like (5), which is ambiguous between readings (5a) and (5b), repeated here for convenience:

(77) Every linguist and philosopher knows the Gödel Theorem.
  a. Everyone who is both a linguist and a philosopher knows the Gödel Theorem.
  b. Every linguist knows the Gödel Theorem, and every philosopher knows the Gödel Theorem.

In Winter (1998)'s analysis of (77), if $\sqcap$ is introduced immediately, this leads to the reading in (77a); if it is introduced after the conjuncts have combined with the determiner and optionally with the verb phrase, the reading in (77b) is generated. On the present account, reading (77a) is obtained by intersection; reading (77b) is obtained by insertion of the silent operators E, *min*, and *dfit* as demonstrated in the discussion of *man and woman* above.

However, the delayed introduction of intersection in Winter (1998) overgenerates. For example, the system does not prevent *No girl sang and danced* from meaning *No girl sang and no girl danced*. To see this, consider the following derivation:

(78)
  a. $[\![\text{no girl}]\!] = \lambda P.\neg\exists x[\mathbf{girl}(x) \wedge P(x)]$
  b. $[\![\text{sang and}_{pair}\text{ danced}]\!] = \langle \lambda x.\mathbf{sing}(x), \lambda x.\mathbf{dance}(x)\rangle$
  c. $(78a)((78b)) = \langle \neg\exists x[\mathbf{girl}(x) \wedge \mathbf{sing}(x)], \neg\exists x[\mathbf{girl}(x) \wedge \mathbf{dance}(x)]\rangle$
  d. Application of $\sqcap$: $\neg\exists x[\mathbf{girl}(x) \wedge \mathbf{sing}(x)] \wedge \neg\exists x[\mathbf{girl}(x) \wedge \mathbf{dance}(x)]$
  e. $= [\![\text{No girl sang and}_{pair}\text{ no girl danced}]\!]$

The problem here is similar to the one facing early accounts of verb phrase coordination in Transformational Grammar via conjunction reduction. By allowing the subject to enter the computation twice and by giving *and* scope over it, such accounts overgenerate in many cases where the subject is a quantifier. My system avoids this problem since *and* is interpreted as local, not delayed, intersection. A sentence like *No girl sang and danced* is interpreted simply by intersecting *sang* and *danced* locally.

To be sure, intersecting *sang* and *danced* locally is also a possible derivation in Winter (1998), and both that system and the one I present here must be prevented from overgenerating. In my case, for example, we need to block the application of the operators involved in the E/CF mechanism to verbs, like *sang* and *danced*. For this reason, I assume that the distribution of silent operators is not free but is constrained by syntax, just like the distribution of ordinary words. This assumption is discussed and defended at length in Winter (2001). Arguably, the restriction of E to the nominal domain is natural since it also has this property when it doubles as a choice-functional operator.

Of course, one could adopt the system of Winter (1998) by constraining the application of $\sqcap$ syntactically as well, for example by requiring pairs to be collapsed at certain nodes including the one that dominates the verb phrase. However, there does not seem to be any natural justification for this constraint. In any case, for the purpose of Winter's approach and of this paper (that is, for the purpose of showing that the intersective theory is viable), one might of course just as well adopt the present system for noun-noun coordination, and avoid the departure from the intersective theory that Winter

(1998) assumes is required by it.

6 The relationship between *and* and *or*

The intersective theory of coordination suggests that there is a close relationship between *and* and *or* in natural language, analogous to the close relationship between intersection and union in many logics. Any set of assumptions surrounding an intersection-based entry for *and* need to be tested with respect to whether they interact correctly with a union-based entry for *or*. This section deals with relationship between *and* and *or* on the present account, and provides an explanation of the typological observation described in the introduction that across languages, disjunction is never associated with collective uses.

Most authors who adopt the intersective theory of coordination assume that it applies in equal ways to *and* and *or*. I will assume the same here. That is, I adopt the following entry for *or* based on Gazdar (1980), analogous to the intersective entry for *and* shown in (17):

(79) $$[\![\text{or}_{bool}]\!] = \sqcup_{\langle\tau,\tau\tau\rangle} =_{def} \begin{cases} \vee_{\langle t,tt\rangle} & \text{if } \tau = t \\ \lambda X_\tau \lambda Y_\tau \lambda Z_{\sigma_1}.X(Z) \sqcup_{\langle\sigma_2,\sigma_2\sigma_2\rangle} Y(Z) & \text{if } \tau = \sigma_1\sigma_2 \end{cases}$$

Bergmann (1982) challenges the intersective theory based on examples that involve noun-noun coordination. The puzzle Bergmann raises is the following: Why are the sentences in (80a) equivalent while those in (80b) are not? The purpose of this section is to provide a solution for Bergmann's puzzle.

(80) a. Every cat and dog is licensed. ⇔ Every cat or dog is licensed.
b. A cat and dog came running in. ⇎ A cat or dog came running in.

For the sentences in (80a), the present system generates (among others) two equivalent LFs, shown in (81) and (82) along with their translations. For convenience, I ignore the existential import of *every* and treat it as simply denoting the subset relation. I treat the verb phrases *came running in* and *be licensed* as unanalyzed predicates. They are distributive predicates, or atom predicates in the sense of Winter (2001), which means that they do not by themselves trigger determiner fitting. The application of *dfit* in (81a) is triggered by the type of the collective predicate *cat and dog*, which is treated in the same way as *man and woman* above. In a slight departure from Winter (1998), who assumes that applying *dfit* changes the pronunciation of *every* to "all", I assume that the pronunciation of *every* is not affected when the conjoined noun phrases are singular.

(81) a. dfit(every)(min(E(cat) and$_{bool}$ E(dog)))(pdist(be_licensed))
b. $\bigcup\{\{x,y\}|\textbf{cat}(x)\wedge\textbf{dog}(y)\} \subseteq \bigcup\{\{x,y\}|\textbf{cat}(x)\wedge\textbf{dog}(y)\wedge\{x,y\} \subseteq \textbf{be\_licensed}\}$

(82) a. every(cat or$_{bool}$ dog)(be_licensed)
b. $\textbf{cat} \cup \textbf{dog} \subseteq \textbf{be\_licensed}$

The translations in (81b) and (82b) are equivalent, as the reader may verify. As for the sentences in (80b), there is no way to generate equivalent LFs for them. For example, the LFs in (83a) and (84a) correspond to the most prominent (if not the only) readings of the two sentences in (80b), and they evaluate to the nonequivalent formulae in (83b) and (84b).

(83) a. dfit(a)(min(E(cat) and$_{bool}$ E(dog)))(pdist(come_running_in))
b. $\exists x \exists y.\mathbf{cat}(x) \wedge \mathbf{dog}(y) \wedge \{x, y\} \subseteq \mathbf{come\_running\_in}$

(84) a. a(cat or$_{bool}$ dog)(come_running_in)
b. $\exists x.(\mathbf{cat}(x) \vee \mathbf{dog}(x)) \wedge \mathbf{come\_running\_in}(x)$

Unlike *and*, which is descriptively ambiguous between intersective and collective uses, *or* has no such seeming ambiguity in any known language (Payne, 1985). As I have mentioned in the introduction and as emphasized by Winter (2001), this provides strong motivation against accounts that attribute collective uses of *and* to this word being ambiguous between an intersective and a collective entry, since such accounts provide no explanation of the fact that *or* is not ambiguous in the same way. The type-shifting account of Winter (2001) provides a general answer to this question. Interestingly, this answer also extends to the present system. As discussed above, I have assumed that a surface string of the shape *N1 and N2* can correspond to the two LFs "N1 $\sqcap$ N2" and "min(E(N1) $\sqcap$ E(N2))". These two structures have completely different meanings. This explains why *and* sometimes looks like intersection and sometimes like collective formation. As for noun-noun disjunction, however, the situation is different. I assume that the same structures are generated: "N1 $\sqcup$ N2" and "min(E(N1) $\sqcup$ E(N2))". You might expect that this incorrectly predicts that *or* is ambiguous in an analogous way to *and*. But these two structures evaluate to almost the same thing, and because of determiner fitting, the remaining difference between them disappears in the course of the rest of the derivation. While "N1 $\sqcup$ N2" underlies the derivation in (82), "min(E(N1) $\sqcup$ E(N2))" underlies the following derivation, which is equivalent to (82).

(85) dfit(every)(min(E(cat)) $\sqcup$ min(E(dog)))(pdist(be_licensed))
$= \text{dfit(every)}(\text{min}(\{P|P \cap \mathbf{cat} \neq \emptyset \vee P \cap \mathbf{dog} \neq \emptyset\})(\{P|P \neq \emptyset \wedge P \subseteq \mathbf{be\_licensed}\})$
$= \bigcup\{\{x\}|x \in (\mathbf{cat} \cup \mathbf{dog})\} \subseteq \bigcup(\{\{x\}|x \in (\mathbf{cat} \cup \mathbf{dog})\} \cap \{P|P \neq \emptyset \wedge P \subseteq \mathbf{be\_licensed}\}$
$= (\mathbf{cat} \cup \mathbf{dog}) \subseteq ((\mathbf{cat} \cup \mathbf{dog}) \cap \mathbf{be\_licensed})$
$= (\mathbf{cat} \cup \mathbf{dog}) \subseteq \mathbf{be\_licensed}$

This can be seen either as a case where the intersective theory of coordination provides independent motivation for the existence of determiner fitting or vice versa, depending on which one of these two assumptions one sees as better established.

While the present system predicts that conjoining nominals can sometimes lead to an interpretation that closely resembles the interpretation of a phrase with disjunction, the converse is not predicted. This seems right in many cases. For example, *A linguist or philosopher came running in* can neither be interpreted as talking about a linguist-philosopher, not as talking about a linguist and a philosopher. To be sure, there are well-known contexts involving free choice in which conjunction does seem to be interpreted as disjunction. For example, sentence (86a) can be paraphrased as (86b) (for discussion see Zimmermann, 2000):

(86) a. Mr. X might be in Victoria or he might be in Brixton.
b. Mr. X might be in Victoria and he might be in Brixton.

This has been taken to suggest that there is a covert operator that maps each connective onto its dual (Barker, 2010). The present approach presents a more asymmetric picture. This is motivated by the fact discussed above that only *and* but not *or* is able to give rise to collectivity effects crosslinguistically. It is not immediately clear in what way the present approach can be extended to the behavior of sentential connectives under free choice.

7 Hydras

As we have seen in the introduction, hydras are relative clauses with multiple heads (Link, 1984), I have argued that they provide evidence that noun-noun coordinations denote predicates of collective individuals. In For example, we have seen that in the following sentence, repeated from (13), the coordination *man and woman* denotes the set of man-woman pairs:

(87) The man and woman who dated each other are friends of mine.

In this brief section, I sketch how hydras are analyzed on the present account. The analysis is straightforward in the case of noun coordination, and no new elements or silent operators are needed. Here is a derivation of sentence (87):

(88) $[\![\text{dfit(the) [(min(E(man) and}_{bool}\text{ E(woman)))} \cap \text{(who\_dated\_each\_other)]}$
$\text{(pdist(are\_friends\_of\_mine))}]\!]$
$= \mathbf{the}(\bigcup(\mathbf{mw\text{-}pair} \cap \mathbf{dated})(\bigcup(\mathbf{mw\text{-}pair} \cap \mathbf{dated} \cap \wp(\mathbf{friends\_of\_mine})))$
$\approx \exists!\{x,y\}.\mathbf{man}(x) \wedge \mathbf{woman}(y) \wedge \mathbf{dated}(\{x,y\}) \wedge \{x,y\} \subseteq \mathbf{friends\_of\_mine}$

This analysis predicts truth conditions that can be paraphrased as "The man-woman couple who dated is a subset of my friends." This seems accurate.

Unfortunately, hydras have the well-known property that for each head cut off, three more need to be dealt with. Link discusses noun-phrase-headed hydras like the following:

(89) the boy and the girl who met yesterday

I see no straightforward way to analyze these kinds of hydras under any of the accounts discussed in this paper, including my own. The main problem seems to be how to compute the presuppositions of each of the two definite determiners.

8 Summary and Outlook

The intersective theory of *and* has been successfully applied to coordination of constituents other than nouns (Winter, 2001). But its application to coordination of nouns has remained elusive and has been taken to require a departure from the intersective theory (Winter, 1998; Heycock and Zamparelli, 2005). I have shown that the intersective theory is not only viable in this case, but arguably preferable since it generalizes to other cases more successfully than the collective theory. The intersective theory straightforwardly delivers the observed behavior of *and* in cases like *liar and cheat*. The main result of this paper is that the intersective theory also predicts the collective behavior of *and* in noun-noun coordinations like *man and woman*, due to the way it interacts with silent operators previously postulated to account for phenomena involving indefinites and collective predicates (Winter, 2001). Essentially, this collective behavior has the same source as the behavior of *some man and some woman*, except that the instances of *some* are silent modifiers rather than overt determiners. Potentially non-disjoint sets, as in *doctor and lawyer*, have made it necessary to adopt a choice-functional analysis of the silent modifiers in question. Coordination of plural nouns, as in *five men and women*, are potentially ambiguous: in this case, there may be either ten or just five people in total. The former case can be dealt with by assuming a silent copy of the numeral, or by raising the type of the nouns before conjoining them so they expect the numeral as an argument. The latter case requires the application of a distributive choice-functional operator, which is independently motivated by exceptional scope of plural numerals that are interpreted distributively.

The hardest nut to crack for anyone wishing to pursue the collective theory is probably coordination of non-upward-entailing quantifiers such as *no man and no woman*. Not only do Heycock and Zamparelli (2005) not give a satisfying account of these conjunctions, it also does not seem easy to give one under *any* approach that takes the basic meaning of *and* to be collective. For this reason alone it seems preferable to make the intersective theory work if one is interested in using generalized quantifier denotations for at least some non-upward-entailing noun phrases.

The intersective theory of coordination suggests that there is a close relationship between *and* and *or* in natural language, analogous to the close relationship between intersection and union in many logics. Any set of assumptions surrounding an intersection-based entry for *and* need to be tested with respect to whether they interact correctly with a union-based entry for *or*. This is the case here. In particular, the present theory explains the typological observation that across languages, *or* is never – descriptively speaking – ambiguous between union-based and collective uses the way *and* tends to be ambiguous between intersection-based and collective uses.

The skeptical reader may be concerned that the approach to coordination advocated here relies on too many silent elements: the Montague lift (16), the minimizer (20), existential raising (21), determiner fitting (25), predicate distributivity (27), the silent version of the indefinite in (36), the choice function binder (38), and the distributive choice function operator in (62). It is worth emphasizing the independent motivation of each of these. The Montague lift is required by any account of coordination of proper names with generalized quantifiers, assuming that coordination can only conjoin like types (Partee and Rooth, 1983) – unless, of course, proper names are treated as generalized quantifiers to begin with (Montague, 1970). The minimizer plays a central role both in the treatment of noun phrase coordination in Winter (2001) and in the present treatment of noun coordination, since it reduces an intersective conjunction to a proxy for collective conjunction. Similar operations that also involve minimization (though admittedly not the same exact operator) are found in various areas of semantics, for example, in E-type analyses of donkey sentences (Heim, 1990). The existential raising operator, as well as intensional versions of it, is also found in analyses of bare plurals and bare mass terms (Chierchia, 1998; Krifka, 2004). Determiner fitting is Winter's answer to the old question of how to correctly model the interaction of generalized quantifiers and collective predicates. Predicate distributivity is Winter's implementation of the effect of the plural on verb phrases, and is similar to the star operator in Link (1983). The silent version of the indefinite is the counterpart of the hybrid choice-functional / quantificational account of the indefinite motivated in Winter (2001). The silent version is also used there to simulate a part of the Montague lift. Finally, the distributive choice function operator is motivated by distributive readings of plural indefinites, as seen above.

As Winter notes, the effect of existential raising can be simulated by the choice-functional mechanism encapsulated in the other operators and so the number of operators involved can be reduced by one. Determiner fitting only applies to words and so it can be applied to the appropriate determiners in the lexicon and then discarded. The distributive choice function operator can probably be decomposed into some version of the independently needed distributive operator and the already-introduced choice function operator. Apart from this, there does not seem to be an obvious way to reduce the number of operators. The question is whether this should be a cause for concern. True, it is only in the presence of these operators that the intersective theory becomes viable for the case of noun coordination. But the phenomena that suggest the presence of all these operators in the grammar are largely independent of coordination. And there does not seem to be an analogous way to use them to make the collective theory viable in the case of coordination of noun phrases.

The analysis in this paper can be extended at least in part to a number of constructions. As discussed in section 7, hydras involving noun-noun coordination find a natural explanation in the present system, though we have seen that hydras involving coordination of noun phrases remain a challenge. Examples involving adjective conjunction such as *the flag(s) is/are green and white* are another interesting test case for theories of coordination (Krifka, 1990; Winter, 2001). The present system can be extended to these examples as follows. First, we move to a mereological setting in which parts of ordinary objects, as well as pluralities of these objects, are explicitly represented as entities in the model. This is independently needed if we decide to pursue a unified analysis of mass terms and plurals (Link, 1983). The extension furthermore requires allowing the E/CF mechanism to apply to adjectives. The derivation of *green and white* proceeds similarly to that of *man and woman* but requires an extra step that applies to the output of the minimizer and collapses each pair in this output into its mereological fusion. The result is that *green and white* denotes the set of all fusions of a green and a white entity, as desired. The extra step is required anyway if one chooses to adapt the present system as a whole into a setting where collective individuals are represented as mereological sums rather than sets. This is required in any case if one wants to extend the present treatment to mass noun conjunctions like *water and wine* in a mereological framework such as Link (1983). A challenge consists in preventing this approach to adjective conjunctions from overgenerating to cases like *#the bridge is long and short* without ruling out *the bridges are long and short* (Winter, 2001). Most long bridges can be divided into a long part and a short part, yet we cannot apply collective predicate coordination in this case.

Overgeneration has not been discussed much in this paper, since the main goal was to show that the intersective theory is able to generate the right collective readings in the first place. However, a well-motivated mechanism that prevents overgeneration would be an essential feature of any grammar or fragment that implements the system presented here. In the absence of such a mechanism, the only thing that prevents dropping a generalized quantifier into a nominal position (in which it would be interpreted as a property of sets) is the good will of the grammar user. For an illuminating discussion of the havoc that a mischievous grammar user who is granted unconstrained access could wreak to silent semantic operators like the E/CF mechanism and the minimizer, see Winter and Schwarzschild (2001). A promising approach is to adopt the category-shifting strategy advocated in Winter (1998, 2001). According to this strategy, silent semantic operators change the semantic category of an expression (e.g. from predicate to quantifier and vice versa) and are triggered by the need to shift the syntactic category of a constituent, rather than by semantic type mismatch.

Furthermore, one may exploit the number agreement system of English to rule out expressions like **two man and woman* which are otherwise expected to be a good way to talk about a man and a woman. Given that *two men and women* fares no better in this respect, one may furthermore replace the naïve theory of the plural adopted here, according to which the meaning of the plural is essentially "one or more", by a more sophisticated theory according to which this meaning is sometimes enriched to "two or more". This cannot happen across the board, since the "two or more" component is not present in downward-entailing and non-monotonic contexts. Thus, one can comply with an instruction to *take five fruits and vegetables* even by taking just one fruit and four vegetables (Y. Winter, p.c.). One possible explanation is that the "two or more" component of the plural might be more appropriately treated as a scalar implicature, as suggested for example by Zweig (2009).

The agreement properties of English noun-noun coordinations are highly interesting in their own right – witness the singular determiner and the plural verb phrase in *this man and woman are in love*, and the contrast with the singular verb phrase in *Every cat and dog is licensed*. Agreement of noun-noun coordinations, both in English and across languages, are of central concern in King and Dalrymple (2004). Determiners and languages differ in whether they allow collective interpretations of singular noun coordinations. This seems to be due to the different ways in which determiners and languages interact with morphological agreement features and their semantic counterparts (Heycock and Zamparelli, 2005). A natural next step to take is to study the interaction of semantic system presented here with number agreement in English and across languages.

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