Distributivity and Dependency

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Abstract

Sentences with multiple occurrences of plural definites give rise to certain effects suggesting that distributivity should be modeled by polyadic operations. Yet, in this paper it is argued that the simpler treatment of distributivity using *unary* universal quantification should be retained. Seemingly polyadic effects are claimed to be restricted to *definite* NPs. This fact is accounted for by the special anaphoric (dependent) use of definites. Further evidence concerning various plurals, island constraints and cumulative quantification are shown to support this claim. In addition, it is shown that also the evidence against a simple *atomic* version of unary distributivity is not decisive. In the (uncommon) cases where distributivity with definites is not strictly atomic, they can be analyzed as dependent on implicit quantifiers.

1 Introduction

The proper use of distributivity operations in the analysis of plurals has been the subject of much debate. While virtually all contemporary theories of plurals assume some version or another of such covert operators, two problems concerning their precise formulation have proven to be especially thorny. One problem is to decide if distributive quantification in natural language is *atomic* or is it a process that quantifies over (arbitrary) sets of atoms. Another question concerns the arity of distributivity operations: whether they are *unary* (=apply to one argument) or *polyadic* (=apply to many arguments simultaneously). Both questions concern the expressibility of natural language semantics. For instance, atomic distribution is a special case of distribution over arbitrary sets of atoms. Hence, a theory that assumes also non-atomic distribution is logically richer than a theory that assumes only atomic distribution. Likewise, theories of polyadic distribution are richer than theories with only unary distribution. Since one of the main goals of semantic theory is to determine the logical expressibility of natural language, the empirical study of distributivity has become central to the investigation of plurality.

Some examples in the literature were taken as evidence that the richer theories are along the right track, and that distributivity operators in the theory of plurals need to be both non-atomic and polyadic. This paper argues against this conclusion. It is claimed that non-atomic and polyadic effects with simple plurals are systematically restricted to plural *definites*. It is shown that these effects can be accounted for using an independent property of definites: their interpretation as (possibly bound) anaphors. Therefore, it is claimed that it is advantageous not to extend the formulation of distributivity operations beyond the weakest, atomic-unary version.

Section 2 reviews some preliminaries on the phenomenon of distributivity and its polyadic effects, as well as some previous proposals to handle them. Section 3 introduces the proposed analysis of these effects using anaphoric definites and unary distribution, and shows some reasons to prefer this proposal to polyadic alternative analyses. Section 4 uses implicit quantification to propose a dependency analysis of non-atomic distribution. Section 5 briefly discusses, and dismisses, the possibility that all cases of quantificational distributivity can be explained away using the anaphoric behavior of definites. The conclusion in section 6 is that distributivity operations are required, but their atomic-unary formulation is sufficient.

2 Preliminaries

2.1 On distributivity

The basic challenge for semantic theories of plurals is the distinction between distributive and collective interpretation. Plural definites clearly exemplify the problem. For instance, the meaning of the ”distributive” predication in sentence (1a) can roughly be paraphrased as in (1b). However, this is impossible in cases of ”collectivity” like (2a), as the unacceptability of (2b) shows.

(1) a. The girls smiled.
    b. Every girl smiled.

(2) a. The girls met.
    b. #Every girl met.

To capture the truth conditions of sentences like (2a), most theories of plurality assume that predicates in natural language can apply to some kind of *plural individuals* (”collections”, ”groups”). The collection denoted by the NP *the girls* corresponds to the set of girls G. Ignoring some interesting but irrelevant questions,[1] the meaning of (2a) is assumed to be as simple as (3).

[1] For instance: What happens when the cardinality of G is less than two? Are sets appropriate for modeling plural individuals?

(3) $\mathbf{meet}'(G)$

Returning to (1a), Scha (1981) proposed to treat also this sentence along the same lines of (3), ascribing the property *smile* to the plural individual G. This implies that (1a) is in fact *not* equivalent to (1b): sentence (1a) is assumed to underspecify how many members of G smile. This seems intuitive, especially in cases where the set G is of a large cardinality. The logical entailment of (1a) by (1b) (provided that there are at least two girls) is explained as a lexical property of the predicate *smile*. We can technically guarantee that by requiring that a predicate like *smile* lexically encodes information that makes $\mathbf{smile}'(G)$ true whenever the number of smiling girls is big relative to the total number of girls.[2] I refer to the general idea that intuitively "distributive" sentences like (1a) can involve predication over plural individuals as the *vagueness* approach to distributivity.[3] Similar assumptions about predicates are common and justified elsewhere in formal semantics. For instance, consider the following question: how much of a car's body should be wet in order for the sentence *the car is wet* to be true? This is normally treated as a question about the lexical meaning of the word *wet* that need not concern the formal interpretation of the sentence.

Most contemporary works on the topic, although occasionally accepting the initial plausibility of the vagueness thesis on distributivity, object to the idea that distributivity of definites can always be reduced to vagueness. Sentence (4a) is a simple case that exemplifies the grounds for this objection.

(4) a. The girls are wearing a dress.

b. $[\![\text{wear a dress}]\!]([\![\text{the girls}]\!])$
$\Leftrightarrow\ (\lambda x.\exists y[\mathbf{dress}'(y) \wedge \mathbf{wear}'(x, y)])(G)$
$\Leftrightarrow\ \exists y[\mathbf{dress}'(y) \wedge \mathbf{wear}'(G, y)]$

Scha's approach requires that the predicate denoted by the complex verb phrase *wear a dress* directly applies to the plural individual denoted by the subject, as illustrated in (4b). While (4a) is intuitively satisfied if every girl is wearing a *different* dress, statement (4b) oddly requires that there is one dress worn by the whole group of girls. Using some postulated lexical information about the predicate *wear* doesn't help much here. This would only add the equally odd information that there is some individual

[2] Scha proposed, following Bartsch (1973), to model such distributivity effects using meaning postulates. According to Scha (1981:p.141), these do not need to be mandatory, but rather can be activated in "some given domain of discourse".

[3] A related question is whether predication over plural individuals is direct or is it an indirect process, involving the "group formation" operator of Link (1984) and Landman (1989). Landman (1996) proposes that predication over pluralities is indirect in this way with all predicates. Winter (1999) distinguishes "set predicates", which allow both direct predication and indirect predication, from "atom predicates", where predication over pluralities is always indirect.

dress that all, or relatively many, individual girls are wearing. Put somewhat differently, the gist of the argument against the vagueness analysis of sentence (4a) is that this sentence can be true while sentence (5) below is false.

(5) There is a dress that the girls are wearing.

In terms of entailment between natural language sentences, this can be observed by noticing the validity of the entailment from (6) below to (4a) and the lack of entailment from (6) to (5).

(6) Every girl is wearing a dress.

The vagueness approach assumes the statement in (4b) to be the only reading of both sentence (4a) and sentence (5). Hence, this analysis does not capture the truth-conditional difference between the two sentences.

Another challenge for the vagueness approach is the binding of pronouns by plural definites. For instance, sentence (7a) below can be interpreted as meaning (7b) (see Heim et al. (1991)), which is hard to explain if the definite denotes a plural individual.

(7) a. The boys will be glad if their mothers arrive.
 b. Every boy will be glad if his mother arrive.

We see that when a plural definite takes scope over another element in the sentence (a singular indefinite, a pronoun, etc.) it may behave like a quantifier over singularities, and not only as a plural individual. The conclusion, against the assumption of the vagueness approach, is that a quantificational treatment of plural definites is justified at least as an option.

Bennett (1974) derives quantificational distributivity in sentences with plural definites by assuming that the definite article is lexically ambiguous. One reading generates a plural individual, another derives a universal quantifier over singularities. There is of course methodological reason not to endorse such a line. The common practice in present theories is to favor instead a *derivational* ambiguity account using optional application of a *distributivity operator*. It is assumed that predication over plural individuals allows optional introduction of a covert operator at some syntactic/semantic level. There are various techniques, but all have the effect of mapping a plural individual to a universal quantifier. Plural definites unambiguously denote plural individuals, which can be optionally ”distributed”. For instance, sentence (8), with a ”mixed” distributive/collective predicate, has roughly two ”logical forms”. The LF in (8a) is responsible for the ”collective reading” (8b), one that is verified in case there is a piano that the girls lifted. (8c) is translated to (8d), which captures ”distributive” situations, those where each girl lifted a (potentially different) piano.

(8) The girls lifted a piano.

a. [the girls] [lifted a piano]

b. $\exists y[\mathbf{piano'}(y) \wedge \mathbf{lift'}(G, y)]$

c. [the girls] D [lifted a piano]

d. $\forall x \in G \exists y[\mathbf{piano'}(y) \wedge \mathbf{lift'}(x, y)]$

Importantly, under the present view there is no sense in which a ”collective” reading like (8b) requires ”collective action” of the girls. This reading is needed only to guarantee that sentence (8) is rendered true whenever the sentence *there is a piano that the girls lifted* is true. This sentence, assumed to have only reading (8b), may be true when the girls acted only collectively (i.e. (8d) is false). However, there is no reason to assume that reading (8b), or the sentence that paraphrases it, are falsified by situations where every girl *independently* lifted the same piano: reading (8b) may still be true in such situations due to the vagueness of predication over the plural individual G.

The introduction of the D operator accounts for (4a). The option of not introducing D accounts for (2a). The alternative derivations lead in both cases to statements that are pragmatically unlikely, namely (2b) and (4b) respectively. These are therefore not attested. On the other hand, (1a) can be read in both ways, either as expressing a universal statement or, alternatively, as a ”vaguely distributive” proposition $\mathbf{smile'}(G)$. In (5) the plural is within a scope island with respect to the indefinite. Hence, unlike (4a), the universal-existential scope reading is correctly not derived using the D operator.

There are certain empirical semantic advantages to this treatment over Bennett’s lexical ambiguity. Familiar is the case of VP conjunctions consisting of one distributive and one collective predicate (see Dowty (1986); Roberts (1987) and Lasersohn (1995) among others). A more recent piece of evidence is the ”double scope” behavior of plural *in*definites, observed in Winter (1997), where the scope of an existential quantifier should be distinguished from the scope of distributivity, indicating that distributivity is not always lexically triggered. Another route followed in order to substantiate the assumption about an invisible distributivity operator is the syntactic treatment in Heim et al. (1991), where D is treated as a covert floating quantifier parallel to overt *each*. In Winter (1998) it is claimed that such a universal operator is independently useful in the flexible semantic framework of Partee (1987) in order to obtain *collective* interpretations of NP coordinations within a unified boolean treatment of *and*.

The compositional implementation of distributivity as universal quantification over singularities is straightforward. Basically, there are two options studied in the literature as for the compositional location of such a distributivity operator:

(9) *On arguments* – the D operator is a function from plural individuals to universal quantifiers over singularities:

$$D^a(x_e) \ = \ \lambda P.\forall y \in x\,[P(y)]$$

(10) *On predicates* – D is a predicate modifier, mapping a unary predicate[4] over singularities to a unary predicates over pluralities:

$$D^p(P_{et}) \ = \ \lambda x.\forall y \in x\,[P(y)]$$

Both options, with the appropriate syntactic implementation, can derive readings like (8d) from representations like (8c). An elaborate discussion of the reasons to adopt one of these options, or a combination of them, will not be given here (see Lasersohn (1995) for a review of some arguments). For our purposes, it is sufficient that both options account for much of the data about distributivity by postulating a *unary* universal quantifier that operates on one plural individual at a time. This operator is furthermore *atomic*: it quantifies over the singularities that constitute the plural individual.

2.2 The codistributivity problem

One of the main pieces of evidence challenging the unary view on distributivity can be exemplified by the following simple sentence.[5]

(11) The soldiers hit the targets.

Consider a situation **S** where the set of soldiers S is $\{s_1, s_2\}$ and the set of targets T is $\{t_1, t_2, t_3\}$. Soldier s_1 hit targets t_1 and t_2, whereas s_2 hit t_3. Intuitively, sentence (11) is true. Sauerland (1994) calls this phenomenon *codistributivity*, a term that I adopt in a descriptive, theory-neutral sense.

The unary approach to distributivity expects four readings to (11), which are roughly paraphrased below.

(12) a. The group of soldiers hit the group of targets. (CC)

b. Every soldier hit the group of targets. (DC)

c. The group of soldiers hit every target. (CD)

d. Every soldier hit every target. (DD)

In the case of (11), the puzzle is whether these four readings are sufficient to capture the codistributivity effect. I will henceforth refer to the general question as the *codistributivity problem*.

[4]The generalization to arbitrary n-ary predicates is straightforward.

[5]Such examples were popularized by Scha (1981). Similar problems had been discussed before by Kroch (1974:p.200-6). Kroch refers to an unpublished manuscript by R. Fiengo (1972), reported to address the same question.

2.3 Previous proposals

Scha (1981), as well as other works[6] propose a simple idea: a sentence like (11) can be true in situations like **S** due to its *Collective-Collective* reading (12a). The reasoning is parallel to Scha's vagueness approach to distributivity in (1a). Namely, (11) is true in **S** because the lexical semantics of the predicate *hit* is vague with respect to distribution to the group elements, just like the meaning of *smile* was claimed to be vague in that respect in (1a). Consequently, the statement $\mathbf{hit}'(S, T)$ can be true in situations like **S**. Arguably, sentences like (11) constitute no challenge to the unary approach to distributivity because it is the CC reading, where no distributor applies, that captures the truth of (11) in **S**.

Much recent work does not accept this proposal. Examples like (11) are considered to support a *polyadic* view on distributivity. This is often implemented using notions like *cover* or *partition*.[7]See Gillon (1987), Gillon (1990), Schwarzschild (1996) and Verkuyl and van der Does (1996), among others, as well as section 4 below for relevant discussion. I exemplify the general idea using Schwarzschild's mechanism. Intuitively, a cover can be defined relative to a list of the predicate's group arguments,[8] i.e. a tuple of sets. A cover is a set of tuples, each of them consisting of coordinates that are subsets of the corresponding arguments. In total, all the elements of the arguments should be "covered" by the cover. Formally, the definitions of particular cases in Schwarzschild (1996:p.69-71,84-85) are subsumed under the following definition.[9]

(13) Let $A_1, ..., A_n$ be sets. A set $C \subseteq \wp^+(A_1) \times ... \times \wp^+(A_n)$ is a *cover* of $\langle A_1, ..., A_n \rangle$ iff for every i, $1 \leq i \leq n$, for every $x \in A_i$, there exists a tuple $\langle B_1, ..., B_n \rangle \in C$ s.t. $x \in B_i$.

Schwarzschild assumes that the context provides sentences that contain group denoting NPs with a cover for the groups. For instance, in a context for (11) where soldier s_1 was shooting at t_1 and t_2, and s_2 was shooting at t_3, the salient cover of $\langle S, T \rangle$, denoted by $Cov(S, T)$, is plausibly $\{\langle \{s_1\}, \{t_1, t_2\} \rangle, \langle \{s_2\}, \{t_3\} \rangle\}$. For Schwarzschild, the distributivity operator is a polyadic universal quantifier over tuples from such covers. Thus, sentence (11) is true iff the following holds.

[6]See Kroch (1974:p.203), Katz (1977:p.127) and Roberts (1987:p.145).

[7]Krifka (1989) and Krifka (1992) use an operator of *summation* to deal with similar effects. The pros and cons below with respect to the cover/partition approach apply to Krifka's proposal as well. A recent use of Krifka's operator for the analysis of reciprocals is given in Sternefeld (1998). See also note 13 below.

[8]It is not clear to me whether this is precisely Schwarzschild's intention. The actual idea might involve a cover of the tuple $\langle E, ..., E \rangle$, where E is the whole domain of entities. This point should not matter for the general exposition, however.

[9]For this definition, recall the following set-theoretical notation. Over a domain E: (i) $\wp(X) = \{Y \subseteq E : Y \subseteq X\}$ is the *power set* of X in E. (ii) $\wp^+(X) = \wp(X) \setminus \{\emptyset\}$. (iii) For sets $X_1, ..., X_n \subseteq E$: the *cartesian product* $X_1 \times ... \times X_n = \{\langle x_1, ..., x_n \rangle : x_1 \in X_1, ..., x_n \in X_n\}$.

(14) $\forall \langle A, B\rangle \in Cov(S,T)[\mathbf{hit}'(A,B)]$

This proposition is true in situation **S**, provided of course that the context indeed determines the assumed cover $Cov(S,T)$.

From a methodological point of view, the vagueness approach can be considered a null hypothesis. Almost all theories of plurality take predication over plural individuals (”collectivity”) as a point of departure. A theory that can reduce codistributivity to this primitive notion is arguably the most minimalistic. In fact, as is the case with respect to Scha’s approach to (1a), I know of no decisive evidence against the vagueness analysis of simple cases like (11).

Schwarzschild’s approach is methodologically less desirable at two points: first, it relativizes the distributivity operator to contextual factors that are poorly understood and therefore reduce the falsifiability of the theory (see below); second, it complicates the distributivity mechanism, which now has to become polyadic. Nevertheless; again we shall see that the vagueness line is unfortunately insufficient. A quantificational analysis is well-motivated in the case of codistributivity as well. I will argue, however, against the polyadic approach to the problem and for an analysis that keeps to the simple unary view on the distributivity operator. The context of utterance will continue to play a major role also in the new proposal.

3 The dependency approach to codistributivity

This section argues that codistributivity phenomena do not provide sufficient evidence for the polyadic approach to distributivity. It is proposed that codistributivity results in many cases from a well-known property of definites: their anaphoric/dependent use in sentences like *every orchestra player admires the conductor*. The dependency approach to codistributivity is sketched in subsection 3.1. Subsection 3.2 shows that vagueness of collective predication cannot be the origin for all codistributivity effects: sentences like *the boys gave the girls a flower* show codistributivity that is irreducible to vagueness. Subsection 3.3 shows some linguistic tests that support the dependency approach and challenge the polyadic approach. These tests are rather complex because we have to eliminate in each case the possibility of a vagueness-based account. The main empirical claims subsection 3.3 makes are the following:

1. Codistributivity does not appear with conjunctive NPs like *Mary and John*, provided that two factors are eliminated: vagueness (as usual) and a ”respectively” interpretation of the conjunctions.

2. Codistributivity with numeral definites like *the four girls* appears as expected by the dependency approach and not as expected by the polyadic analysis.

3. Codistributivity appears beyond island boundaries, as the dependency approach expects and polyadic distribution does not.

Other effects that have to be taken into account while developing the empirical argument involve cumulative quantification (subsection 3.4) and dependent plurals as in *unicycles have wheels* (subsection 3.5). By way of summarizing the complex empirical picture, subsection 3.5 also shows some potential counter-examples to the present line and explains how they are to be accounted for.

3.1 Dependent definites and codistributivity

That definites can be used in a way that is comparable to lexical anaphors is a well-known fact.[10] Consider for example sentence (16), uttered in context (15).

(15) At a shooting range, each soldier was assigned a different target and had to shoot at it. At the end of the shooting we discovered that

(16) every soldier hit the target.

In this example, the singular definite *the target* in (16) behaves as if it were an anaphor (e.g. *his target*) "bound" by the quantificational subject. The analogy is justified because in the context of (15) there is no "globally" unique target to which the definite can possibly refer. Every soldier has "his own" unique target. To account for this use of definites is a hard task. Chierchia (1995:ch.4) argues that definite descriptions should be syntactically analyzed with a phonologically null variable. This variable, just like an overt pronoun, can be either "contextually bound" (e.g. by a coreferential NP or a "donkey" antecedent) or "syntactically bound" by a c-commanding antecedent as in (16). Partee (1989), anticipating an idea along these lines, objects to it on various grounds. Without attempting to settle the matter here, let us just accept the anaphoric behavior of definites as a fact about natural language.

Plural definites are no exception to this rule. The following minimal variation of (15) and (16) shows a similar effect.

(17) At a shooting range, each soldier was assigned a different *set* of targets and had to shoot at *them*. At the end of the shooting we discovered that

(18) every soldier hit the target*s*.

Since we assume unary distributivity, the subject of (11), repeated in (19) below, can be interpreted as a universal quantifier, similarly to the subject of (18). Hence, sentence (19) should have a reading that is comparable to (18).[11]

[10] See Partee (1989) for a broad discussion of many other kinds of expressions that show similar behavior.

[11] The reading is not *equivalent* to (18) because of the "dependent plurality" effects to be discussed in section 3.5.

(19) The soldiers hit the targets.

I take this point to be an important clue about the origins of codistributivity.[12] Note, however, that I do not suggest that the *only* reading of (19) that can possibly give rise to codistributivity is the dependent reading paraphrased by (18). As mentioned, also the vagueness approach is quite plausible in such simple cases and there is no solid reason I know to rule it out. On the other hand, now we have an additional factor to play with: in addition to a covert distributivity operator, also anaphoricity of definites can be covert. Therefore, also distributed definites can lead to codistributivity effects, not only collective ones.

Somewhat more vividly, consider the paradigm examples below in context (17).

(20) a. The soldiers *each* hit *their* targets.

b. The soldiers *each* hit the targets.

c. The soldiers hit *their* targets.

d. The soldiers hit the targets.

In (20a) both distributivity and anaphorical dependency are "overt". In (20b) distributivity is overt and dependency is covert. In (20c) the situation is the opposite. There is no reason to assume that the covert phenomena that are independently "observed" in (20b) and (20c) cannot appear in parallel in (20d)(=(19)). Of course, in this case also the simpler collective reading $\mathbf{hit}'(S, T)$ should be available, which is subject to the vagueness reasoning.

To be a bit more explicit, we can assume that a sentence like (16), with a singular dependent definite, can have the reading (21) below.

(21) $\forall x[\mathbf{soldier}'(x) \rightarrow \mathbf{hit}'(x, t(x))]$
t – a contextually salient function from individuals to individuals mapping each soldier to a target

In context (15), we assume that the salient t is the function mapping any soldier to the unique target he was shooting at. For expository purposes (alone), let me adopt Chierchia's assumption, modeling dependent definites using an implicit syntactic variable. If the proposal is correct, this reading is derived by a Logical Form along the lines of (22), where *target*(x_1) is interpreted as a functional (relational) noun denoting the function t.

(22) [every soldier]$_1$ [hit [the target(x_1)]]

[12] Sauerland (1994) briefly mentions this possibility of modeling codistributivity using dependency, but rejects it, for a reason to be discussed in section 3.3.5.

The treatment of (18) is similar, but we have the liberty of either distributing the object or not. For expository purposes we can use the Heim et al. (1991) notation for the distributors. Summing up, the two LFs with the dependent reading of the object are as follows.

(23) a. [every soldier]$_1$ [hit [the targets(x_1)]]

b. [every soldier]$_1$ [hit [[the targets(x_1)] D_2]]

The statements that correspond to these LFs are given below.

(24) a. $\forall x[\mathbf{soldier'}(x) \rightarrow \mathbf{hit'}(x, T(x))]$

b. $\forall x[\mathbf{soldier'}(x) \rightarrow \forall y \in T(x)\ \mathbf{hit'}(x, y)]$

T – a contextually salient function from individuals to individuals mapping any soldier to a set of targets

In the context of (17), we assume that T maps every soldier to the set of targets he was shooting at. In (19), under the distributive construal of the subject and the dependent reading of the object the situation is quite the same. The relevant LFs of (19) are:

(25) a. [[the soldiers] D_1] [hit [the targets(x_1)]]

b. [[the soldiers] D_1] [hit [[the targets(x_1)] D_2]]

The derived statements are, correspondingly, the above (24a-b). Reading (24b) captures a codistributivity effect in (19). For instance, assume soldier s_1 was shooting at targets t_1 and t_2, and soldier s_2 was shooting at t_3. Therefore, the T function describing this shooting will satisfy (24b) if each soldier also hit the target(s) he was shooting at. This is desired, as (19) is verified in **S**. Also reading (24a) is useful for similar sentences to (19), as will become obvious in the next section.

What do these considerations give us in addition to the vagueness approach? Not too much, as long as we keep concentrating on what Langendoen (1978) calls ”elementary plural relational sentences” (EPRSs): sentences of the form *plural definite – verb – plural definite*. These can hardly distinguish between the different approaches to codistributivity. In the rest of this section, I consider a somewhat broader range of data that can help us to decide between the three accounts.[13]

[13] I do not address below the issue of reciprocity, which has been recently treated in Sternefeld (1998), following Langendoen (1978), Krifka (1989) and Krifka (1992), using polyadic distribution. For instance, Sternefeld analyzes sentence (i) below as involving polyadic distributivity on a three place predicate *write_to*.

(i) John read the letters they wrote to each other.

In such cases as well, dependency (here, of the pronoun *they*) is an alternative to polyadic distribution. Movement of *each* as in Heim et al. (1991) generates the following LF.

3.2 The insufficiency of the vagueness approach

The same problem of sentence (4a) for Scha's view on distributivity appears with the vagueness account of codistributivity. Consider sentence (26) in a context where every boy met some girls.[14]

(26) The boys gave the girls a flower.

Clearly, for (26) to be true it is sufficient that there are *different* flowers given by the boys to the girls at different meetings. To be concrete, consider the situation in (27). Sentence (26) is intuitively true in the context of the meetings in (28).

(27) The boys are John and Bill. The girls are Mary, Sue, Ann and Ruth. John gave Mary and Sue a flower. Bill gave Ann and Ruth a flower.

(28) John met Mary and Sue. Bill met Ann and Ruth.

Scha's vagueness line allows only one reading of sentence (26), the doubly collective reading given in (29) below, to admit the codistributive interpretation of (26).

(29) $\exists z[\mathbf{flower'}(z) \wedge \mathbf{give'}(B, G, z)]$

This reading requires that (at least) *one* flower was given by the group of boys to the group of girls. Nothing in situation (27) guarantees the existence of such a flower. If this were the case, sentence (30) should have been true in situation (27), which is not necessarily the case.[15]

(30) There was a flower that was given by the boys to the girls.

(ii) John read [the letters D_1] [[each$_2$ (they(x_1))] [wrote to the others]]

Once the pronoun *they* depends in this way on the (distributed) letters, the *each* does no longer generate too strong truth-conditions, as in the original analysis of Heim, Lasnik and May that Sternefeld criticizes. Note that pronouns, like definites, show the dependent behavior, as exemplified in (iv), which under context (iii) can be interpreted as equivalent to (v).

(iii) Every boy met some girls.

(iv) Every boy gave them a flower.

(v) Every boy gave the girls he met a flower.

[14]This example was pointed out to me by Dorit Ben-Shalom.

[15]The following examples are more dramatically convincing:

(i) The men killed the women with a gun.

(ii) There is a gun with which the men killed the women.

Sentence (i) can certainly be true when (ii) is false.

Thus, (29) does not capture the codistributivity in (26), just like (4b) does not capture the *dis*tributivity effect in (4a).

Once we allow a unary distributivity operator, sentence (26) gets also the following readings, in addition to reading (29).[16]

(31) a. $\forall x[\mathbf{boy}'(x) \rightarrow \exists z[\mathbf{flower}'(z) \wedge \mathbf{give}'(x, G, z)]]$

b. $\forall y[\mathbf{girl}'(y) \rightarrow \exists z[\mathbf{flower}'(z) \wedge \mathbf{give}'(B, y, z)]]$

c. $\forall x \forall y[[\mathbf{boy}'(x) \wedge \mathbf{girl}'(y)] \rightarrow \exists z[\mathbf{flower}'(z) \wedge \mathbf{give}'(x, y, z)]]$

In the situation described in (27), we can paraphrase these readings respectively as follows.

(32) a. For each boy there was a flower that he gave Mary, Sue, Ann and Ruth.

b. For each girl there was a flower that she was given by John and Bill.

c. Each boy gave each girl a flower.

No one of these readings allows sentence (26) to be analyzed as true in situation (27).[17]

The conclusion is that the codistributivity effect in (26) cannot be accounted in the vagueness approach, even when supplemented by a unary distributive operator. We find many other similar codistributivity effects that are not reducible to vagueness in this way. For instance, consider the following b examples under the a contexts.

(33) a. Context: in figure 1, Mary and Sue are John's children and Ann and Ruth are Bill's children.

b. The fathers are separated from the children by a wall.[18]

(34) a. Context: Every circle contains two triangles (figure 2).

b. The circles are connected to the triangles by a dashed line.

For similar reasons to the ones mentioned above with respect to (26), these cases too show that there is no general way to analyze codistributivity as vagueness of predication over plural individuals. It should be stressed however that these examples do not show that the vagueness proposal is *incorrect*. For simple cases like (19) it may well be one of the possible analyses. The lesson is only that the collectivity-vagueness line

[16]Thanks to Roger Schwarzschild for pointing out to me the potential relevance of these readings.

[17]Readers who may find this judgement subtle with respect to (32a) or (32b) should consider the more atrocious example of note 15.Suppose that John killed Mary with a gun and that Bill killed Mary with another gun. The sentence *the men killed the women with a gun* can be interpreted as true in this situation. Certainly, however, it does not follow that for each man there was a gun with which he killed Mary and Sue, nor does it follow that for each woman there was a gun with which she was killed by John and Bill.

[18]Based on an example from Sauerland (1994).

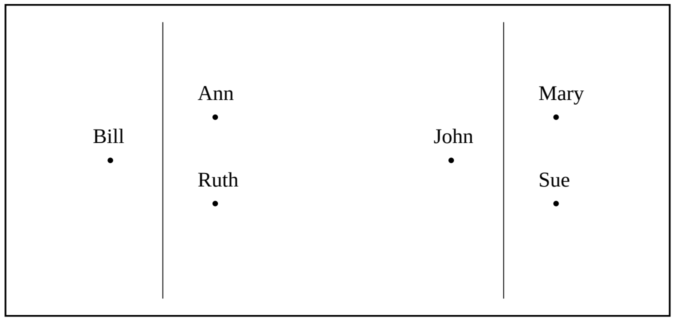

Figure 1: fathers and children

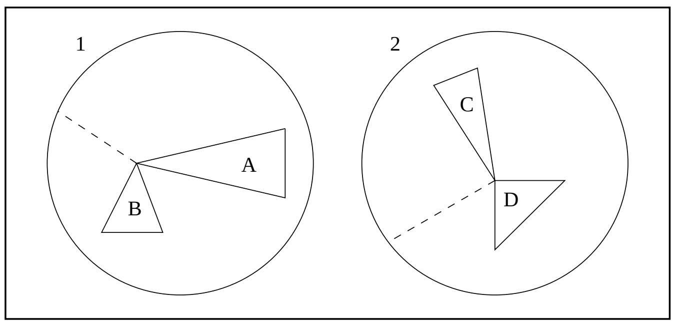

Figure 2: circles and triangles

is descriptively *insufficient* and that a quantificational analysis is needed for treating codistributivity as much as it is needed for the simpler distributivity phenomena discussed in subsection 2.1. When studying this quantificational mechanism, we should be careful not to draw hasty conclusions about its nature from phenomena that may in principle result from vagueness effects. Therefore, let us adopt the following methodological principle.

The "beware of vagueness" principle: cases where lexical vagueness of predicates may in principle lead to (co)distributivity effects are a bad test for quantificational theories of (co)distributivity.

The easy method of letting an indefinite be in the scope of the codistributive plural definites will be followed in most of this section. In subsection 3.3.5 we will meet another way to eliminate potential interference of vagueness.[19]

[19] Landman (1996) proposes yet another test. Landman points out that a sentence like (i) is true in the situation in (ii) but false or odd in (iii).

(i) The women gave birth to the children.

(ii) There are two women with two children each. The women = the two women. The children = the four children.

Let us see how the dependency approach and the polyadic analysis of codistributivity deal with the quantificational effects of codistributivity exemplified above. Sentence (26), repeated below as (35), is analyzed in the dependency approach by assuming that *the girls* is interpreted anaphorically using a *function* G, mapping each boy to ”his” contextually salient set of girls.

(35) The boys gave the girls a flower. (=(26))

In the context of (28) the G function maps every boy to the girls he met. Under this assumption, similarly to (19), unary distributivity predicts two ”surface scope” readings of (35) that give rise to codistributivity effects.[20]

(36) a. [[the boys] D_1] [gave [the girls(x_1)] [a flower]]

b. $\forall x \in B \exists z[\mathbf{flower'}(z) \wedge \mathbf{give'}(x, G(x), z)]$

(37) a. [[the boys] D_1] [gave [[the girls(x_1)] D_2] [a flower]]

b. $\forall x \in B \forall y \in G(x) \exists z[\mathbf{flower'}(z) \wedge \mathbf{give'}(x, y, z)]$

Reading (36) captures the truth of (35) in a situation where each boy gave a flower to the *group* of girls he met (e.g. as a shared present). Reading (37) is true if each boy gave *each* girl he met a flower. The only assumption we had to make in order to achieve this analysis of codistributivity is that *the girls* is interpreted anaphorically to *the boys*. In situation (27) the vagueness approach to the truth of (35) is excluded, so I must claim that the codistributivity effect here is due to one of the dependent readings above. I think this claim is plausible given that the following sentence, with an explicitly distributive subject, seems to require the same contextual background that is needed to verify (35) in situation (27) (e.g. the meeting context (28)).

(38) Every boy gave the girls a flower.

Under the *polyadic* approach to codistributivity, the reading assigned to (35) is:

(iii) There are four women, two of them with only one child, two with no child at all. The women = the four women. The children = the two children.

Landman argues that if (i) could be true in (ii) by virtue of a vague ”group action” reading, it should have also been true in situation (iii) due to the same construal. Although I accept this reasoning, I find it harder to follow for ”experimental” purposes.

[20]That is to say, readings where *the boys* takes syntactic scope over *the girls*, taking scope over *a flower*. There are other codistributive readings perhaps when scope matters are considered. A detailed discussion of which of these ”inverse scope” readings are in fact generated would lead us to complex matters like weak crossover with dependent definites (see Chierchia (1995:ch.4). Be Chierchia’s claims correct or not, I don’t know of places where (un)availability of such additional readings would lead to interesting predictions. I therefore choose to leave these particular scope questions (unlike the ones of subsection 3.3.5) to further research.

(39) $\forall\langle X,Y\rangle \in Cov(B,G)\exists z[\mathbf{flower'}(z) \wedge \mathbf{give'}(X,Y,z)]$

Schwarzschild's strategy is to assume a cover of $\langle B,G\rangle$ that is triggered by the context (28). A relevant cover for $\langle B,G\rangle$ is the following.

$$\{\langle\{\mathbf{j'}\},\{\mathbf{m'},\mathbf{s'}\}\rangle,\langle\{\mathbf{b'}\},\{\mathbf{a'},\mathbf{r'}\}\rangle\}$$

This cover makes sentence (35) equivalent to (36b) (the "DC" reading). Another likely cover is the one below.

$$\{\langle\{\mathbf{j'}\},\{\mathbf{m'}\}\rangle,\langle\{\mathbf{j'}\},\{\mathbf{s'}\}\rangle,\langle\{\mathbf{b'}\},\{\mathbf{a'}\}\rangle,\langle\{\mathbf{b'}\},\{\mathbf{r'}\}\rangle\}.$$

This cover captures the "DD" interpretation of sentence (37b).

Note that Schwarzschild's cover technique is more permissive than the dependency analysis in being inherently *non-atomic*.[21] For instance, suppose that in the context (27)-(28) of sentence (35) another boy, say George, joined Bill in his meeting and *together with him* gave a flower to Ann and Ruth (as a present from both). Sentence (35) is intuitively true. In Schwarzschild's approach this can be captured by covers like the above, by simply replacing $\{\mathbf{b'}\}$ by $\{\mathbf{b'},\mathbf{g'}\}$. The dependency analysis in (36) and (37) does not capture this fact, because the distribution over boys in these analyses is atomic. We will get back to this potential problem in section 4.

3.3 Deciding between polyadic distribution and dependency

Both the dependency approach and the polyadic cover analysis overcome the main difficulty cases like (35) pose to the vagueness approach. Both deal with codistributivity using a *quantificational* mechanism, which enables to give the definite(s) a universal quantifier scope over the indefinite, as intuitively required. On the other hand, because of the appeal to contextual factors both lines suffer from a *falsifiability* weakness. How can we verify that the function G in (36) and (37) mapping boys to girls they met is indeed the relevant one? How is the cover for (39) chosen? In this aspect I believe that the present approach has a methodological advantage. The analysis of sentences like (38) requires a similar assumption on the interpretation of the definite object. Hence, the relevant function establishing the dependency can be independently tested with such sentences. Note that this test is relevant only when the vagueness possibility is eliminated as in (35). In simple cases like (19), vagueness may play a role and allow the sentence in contexts where (18) may be inappropriate.[22] Schwarzschild's proposal does not make any additional prediction: as far as I know, when some cover is assumed for a sentence in a certain context, no method is proposed to show that the assumed

[21] On the other hand, the dependency analysis is more permissive than the cover analysis in being *non-exhaustive*, as discussed in subsection 3.3.3.

[22] For more on this point, see section 3.5.

salient cover is independently relevant to other sentences in the same context. This is a methodological advantage of the dependency analysis over the polyadic approach. Let us turn now to empirical differences between the two methods that show further advantages of the dependency view.

3.3.1 Proper name conjunctions

Reconsider sentence (33b), restated below as (41a). Under context (40) (=(33a)), contrast (41a) with (41b).

(40) Context: in figure 1, Mary and Sue are John's children and Ann and Ruth are Bill's children.

(41) a. The fathers are separated from the children by a wall.
b. John and Bill are separated from Mary, Sue, Ann and Ruth by a wall.

While (41a) is true in this situation, sentence (41b) is false or distinctly odd. A plausible reaction upon hearing such a sentence in this situation is *come on, you're wrong, John is not separated from Ann and Ruth*.

Mechanisms of polyadic distribution like the cover mechanism are special devices for predication over *plural individuals*. The conjunctions in (41b) must have a plural individual denotation like the definites in (41a), as both kinds of NPs pass all tests for collectivity. Hence, the polyadic approach expects no semantic difference between the two cases. It may be claimed that there are pragmatic factors that are responsible for this contrast by way of affecting the determination of the cover, but I know of no good account of such effects. The present dependency approach embodies an assumption about *anaphoric* expressions. Definite descriptions have an anaphoric use, proper names don't.[23] Therefore, the dependency view correctly expects no codistributivity effect in (41b). Similar contrasts appear with the following variations of (35) and (34b), considered under the same related contexts.

(42) John and Bill gave Mary, Sue, Ann and Jane a flower.

(43) Circles 1 and 2 are connected to triangles A, B, C and D by a dashed line.

Note that sentence (44) below, a minimal variation on (41b), may possibly show a marginal codistributivity effect, with a "respectively" reading. However, this is an

[23] We could have dwelt on examples like the following:

(i) Every woman has two children named John and Bill. Every woman likes John and hates Bill.

But this would have been irrelevant. Even if such puzzling cases are coherent, these potentially dependent uses of proper names are unlikely in (41b) and anyway cannot derive a non-existent codistributivity effect. The reason is that *Ann*, for instance, cannot be interpreted as "dependent on *John*".

independent property of conjunction that presumably has nothing to do with covers of plural individuals, because also *predicate* conjunctions as in (45) show the same behavior.

(44) John and Bill are separated from Mary and Sue AND Ann and Ruth (respectively) by a wall.

(45) John loves and hates Mary and Sue (respectively).

Thus, ”respectively” effects with conjunctions (with or without the overt adverbial) may independently create a codistributivity interpretation that is captured neither by dependency nor by polyadic distribution. It is however easy to eliminate such potential effects by using conjunctions like *John and Bill* and *Mary, Sue, Ann and Ruth* (as in (41b) above), which do not match in the number of the conjuncts, hence rule out a *respectively* effect.

3.3.2 Numeral definites

Consider the sentences in (46a-b) as continuations to (46) in same context of (33).

(46) In figure 1, each father is standing next to his two children. However,

a. the (two) fathers are separated from the two children by a wall.

b. every father is separated from the two children by a wall.

Sentence (46a) is OK in this context, as is (46b). Consider however the following examples.

(47) a. the (two) fathers are separated from the *four* children by a wall.

b. every father is separated from the *four* children by a wall.

Both (47a) and (47b) are false, or highly strange. It may be thought that this is because the context in (46) is less appropriate for the latter couple of examples, as it does not stress enough the total number of children. This is unlikely, however, as the following context does emphasize the number of girls and still ameliorates neither of the examples in (47).

(48) In the figure we see two fathers. Each of them is standing next to his two children. In total, therefore, we see four children here.

Once more, we see a parallelism between the (un)availability of dependency (in the b's) and codistributivity (in the a's), as expected in the present approach. Schwarzschild's line expects the opposite pattern. In (46a), the mechanism does not explain why the number *two* in *two children* is possible at all. Conversely, in (47a), the arguments are coreferential with the arguments of (33). Consequently, the same cover analysis should be in principle available. Similar modifications of (35) and (34) show similar contrasts in the corresponding contexts.

(49) a. The (two) boys gave the two girls a flower.

b. Every boy gave the two girls a flower.

c. #The (two) boys gave the four girls a flower.

d. #Every boy gave the four girls a flower.

(50) a. The (two) circles are connected to the two triangles by a line.

b. Every circle is connected to the two triangles by a line.

c. #The (two) circles are connected to the four triangles by a line.

d. #Every circle is connected to the four triangles by a line.

3.3.3 Exhaustivity

Reconsider sentence (51b) below in context (51a), but now in the situation depicted in figure 3.

(51) a. Context: Every circle contains two triangles (figure 3).

b. The circles are connected to the triangles by a dashed line.

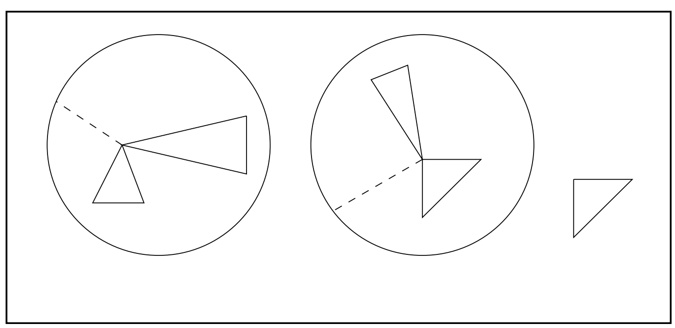

Figure 3: exhaustivity

Sentence (51b) can now be interpreted as true in this situation, although one of the triangles in the figure is not contained in any circle. Without further assumptions, this is unexpected in the cover analysis, which, as its name implies, requires every triangle to be ”covered”.[24]

[24] To prevent exhaustivity of Schwarzschild’s cover analysis, Brisson (1998) adds some such additional assumptions to the mechanism.

In the dependency analysis, by contrast, it is only required that every circle is connected to the relevant triangles and there is no requirement that all the triangles are covered. This prediction is in agreement with intuition.

3.3.4 More dependent definites

The thesis that this paper strives to promote is that codistributivity effects are not exclusively related to plurality. Dependency of definites is independent of number. The kind of quantificational antecedent for the definite should not matter for establishing the anaphorical link. The antecedent can be a ”covertly distributed” plural definite, as in most of the examples above. It can be an ”overtly distributed” definite as in (20b). It can also be a universal quantifier as in (16) or (18).

Of course, this does not exhaust the range of possible quantificational elements. Consider for instance the following example.

(52) a. Context: Every circle contains some squares (figure 4).

b. But only $\left\{\begin{array}{c}\text{one circle}\\ \text{circle 1}\end{array}\right\}$ is connected to the squares by a double arrow.

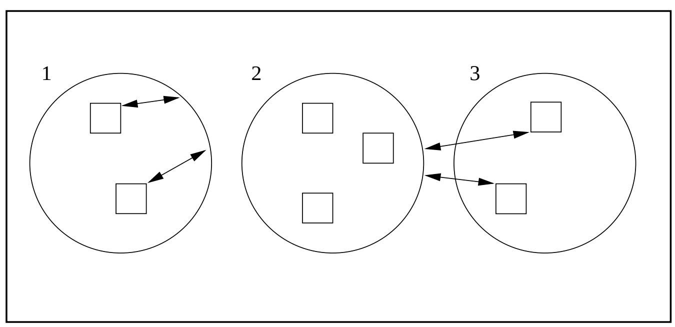

Figure 4: circles and squares

Intuitively, (52b) is true in the given situation and context. Note, however, that circle 1 in figure 4 is not the only one connected to some squares or other. Circle 2 is in fact also connected to squares, but not to the squares it contains. This shows that the definite in (52b) cannot invariably refer to the set of squares in the picture. If this were the case, the sentence should have been univocally false, as it is indeed when uttered ”out of the blue”, without a context like (52a). Within such a context, however, the definite is best analyzed as anaphorically dependent on the subject, interpreted roughly as *the squares it contains*.

Another example for non-universal antecedents is the following variation on (35).

(53) a. Context: Every father has some children and likes them.

b. But only $\left\{ \begin{array}{l} \text{one father} \\ \text{Bill} \end{array} \right\}$ sent the children a present.

Assume the fathers are John and Bill. Bill sent his children a present and John also sent a present, but not to his own children, but rather to Bill's children. Sentence (53b) can nevertheless be read as true, similarly to the former example.

Such facts are not very much surprising given what illustrated above, but they strengthen the present claims about the centrality of the dependent reading of definites.

3.3.5 Islands and codistributivity

Sauerland (1994), anticipating an anaphorical account of codistributivity as an alternative to the polyadic one, proposes an interesting test to distinguish between the two methods. If codistributivity is analyzed using an anaphoric mechanism, it is expected that a definite is allowed to "codistribute with" (=depend on) another NP whenever this NP c-commands it. The polyadic approach expects codistributivity to be more restricted: only when the two NPs are co-arguments of the same predicate can they codistribute. Sauerland attempts to use this theoretical observation as an argument in favor of the polyadic analysis. Let us first observe however that codistributivity can appear beyond island boundaries (a fact not mentioned by Sauerland). This will show that the dependency analysis is necessary at least for the analysis of *some* codistributivity effects that the polyadic approach alone cannot account for. Consider the following examples.

(54) Context: Every company bought some new computers.

a. The companies will go bankrupt if the computers are not powerful enough.

b. The companies that will use the computers efficiently will succeed.

c. The companies will have to start using the computers and adapt to some other new technologies in order to succeed.

In the three cases we have a codistributivity effect. To see that, consider for instance (54a) in a situation where the companies referred to are: Mitsubishi, which bought two enormous mainframes, and a small architect company, which bought two PCs for its account management. Sentence (54a) does not suggest that Mitsubishi's success depends on the specifications of the PCs. Only *its own* computers matter. Similarly for the other company. The case is quite the same in (54b) and (54c). In all three cases, one definite c-commands the other, hence dependency is allowed. The cover approach to codistributivity has to analyze (54a) along the following lines:

(55) $R = \lambda x.\lambda y.[x$ will go bankrupt if y is not powerful enough$]$

$\forall \langle A, B \rangle \in Cov(\text{companies}, \text{computers})[R(A)(B)]$

To get to this analysis, we must extract *the computers* from the conditional adjunct island in order to form the predicate R. This is highly unlikely, as adjunct islands are known to be scope islands for all other cases of quantification. The same applies to the Complex NP and the Coordinate Structure islands in (54b) and (54c). Such syntactic constructions form an independent motivation for the dependency view.[25]

Cases as in (54) show an advantage of the dependency analysis of codistributivity over the polyadic analysis. Sauerland discusses a different example and uses it to argue that it is the polyadic approach that is preferable. The example involves a context where fathers are watching their children playing a game that only one of them can possibly win. Sauerland claims that (56a) is better than (56b), which may be correct.[26]

(56) a. The fathers expected the children to win.

b. The fathers expected the children would win.

In (56b), unlike (56a), *the children* is within a tensed clause, which is sometimes considered to be a scope island. Sauerland argues that this is the reason for its questionable status, according to the polyadic approach. The dependency line expects no such contrast, as in both cases one definite c-commands the other.

I see some weaknesses to this argument:

1. The contrast in not so clear in other contexts. Consider for instance a context where every father sent his child(ren) to a game, where each of the children played a different match against an adult called John. In this context codistributivity in both sentences seems possible, especially with a continuation like *but they were all wrong because John won all of the matches*.

2. What Sauerland assumes about the restrictions on the distribution of anaphoric definites is the null hypothesis, but it is not clear that this is the case in his examples. Assume every father has *two* children. The couples played a game with each other that only one couple can possibly win. Sauerland's judgement with respect to (56) equally holds. However, the following contrast does not seem less sharp than in (56).

   (57) a. Every father expected the children to win.

   b. Every father expected the children would win.

   Thus, the same reasons that are responsible for the contrast in (57), with dependent definites, may be responsible for (56) too.

[25]Note that cases as in (54) cannot be accounted by the vagueness approach, as the relation between the two definites is not a syntactic unit, let alone a lexical one.

[26]Some English speakers do not accept the contrast at all and consider both sentences equally bad. In Hebrew, however, I think the contrast exists if we add *that* to the tensed clause in (56b).

3. If (56) is evidence for polyadic distributivity, we must expect the following sentence to be just as good as (56a) in case there are two fathers (and therefore four children) in the situation just mentioned.

   (58) The (two) fathers expected the four children to win.

   This is clearly not the case.

4. Sauerland's argument draws on an assumption that tensed clauses are scope islands. This assumption is debatable and theoretically costly, as tensed clauses are not islands for extraction (see Reinhart (1997)). To say the least, it is not evident that in such constructions the polyadic approach works as Sauerland expects.

3.4 Codistributivity and cumulative quantification

In addition to codistributivity of plural definites, Scha's work pointed out another important fact he called *cumulative quantification.* Scha's example is given in (59) below.

(59) 600 Dutch firms use 5000 American computers.

(60) The total number of Dutch firms that use an American computer is 600 and the total number of American computers used by a Dutch firm is 5000.

Scha argues that sentence (59) can be read as equivalent to (60). I henceforth accept this commonly agreed judgement, which is a hard challenge to any theory of quantification.[27] Krifka (1989) and Krifka (1992) claims that his polyadic mechanism of summation, which correctly captures some cases of codistributivity, handles also the cumulative interpretation of (59). Roberts (1987:p.148) mentions a proposal by Barbara Partee that attempts to treat (59), similar to Roberts's approach to codistributivity, as a case of vagueness.

It is important to note that these approaches to cumulative quantification cannot work without further assumptions. The reason is that cumulative quantification appears with non-upward-monotone quantifiers.[28] For instance, (61) has the reading (62).

(61) Exactly 600 Dutch firms use exactly 5000 American computers.

(62) The total number of Dutch firms that use an American computer is exactly 600 and the total number of American computers used by a Dutch firm is exactly 5000.

[27] Some caution is required with respect to the pretheoretical declaration of (60) as a *reading* of (60). Anyway, (60) certainly *entails* (59) and this fact on its own is problematic enough.

[28] Scha, in fact, analyzes also the NPs in (59) as non-upward, so his reading of (59) is equivalent to (61).

A recent analysis of cumulative quantification that takes non-upward-monotonic quantifiers into account is Landman (1997). Landman crucially relies on the indefiniteness of NPs that participate in cumulative relations, using a sophisticated distinction between their truth-conditions and conversational implicatures. Therefore, Landman's theory, like the present proposal, views cumulativity and codistributivity as two different processes.[29] At present, I know of no account of cumulative quantification that can deal both with codistributivity and cumulation of non-upward-monotone quantifiers using the same mechanism.[30]

Whatever the theory of cumulative quantification may be, the points just mentioned raise a potential pre-theoretical objection to the present account of codistributivity. Can it be that codistributivity should be treated as an instance of the same problem cumulative quantification exemplifies? Note that the strategies above for paraphrasing (59) and (61) can capture a codistributivity effect in (19) using a distributive reading for both definites:[31]

(63) Every soldier hit a target and every target was hit by a soldier.

This reading is true in the aforementioned situation $\mathbf{S}$. Thus, it may be argued that any imaginable theory of cumulative quantification should automatically cover codistributivity and, therefore, the present proposal (as well as competing ones) is just not general enough to be interesting.

A full answer to this possible objection would require a full analysis of cumulative quantification in cases like (59) and (61), which is beyond the scope of this paper. However, there are two reasons to question an identification of codistributivity of plural definites with cumulative quantification that should be mentioned here. First, all known examples for cumulative quantification as in (59) and (61) are when the cumulated NPs are syntactically close. By contrast to (54a) for instance, consider the following sentence.

(64) Exactly 600 companies will go bankrupt if exactly 5000 computers are not powerful enough.

The following sentence is highly unlikely to paraphrase a reading of (64).

(65) The total number of companies that will go bankrupt if a computer is not powerful enough is exactly 600 and the total number of computers x such that a company will go bankrupt if x is not powerful enough is exactly 5000.

[29] This seems to have been Scha's position as well, as the different mechanisms he proposed for codistributivity and cumulative quantification imply.

[30] Schein (1993) is a possible exception, but this work's pre-assumptions are radically different than those of other works on plurality. A detailed discussion of Schein's ideas must therefore be deferred to another occasion.

[31] This is the strategy of Langendoen (1978) for paraphrasing such sentences.

To see the contrast more vividly, consider the following text:

(66) It is not true that more and more companies depend on more and more computerized systems nowadays. In fact, last year exactly 600 companies went bankrupt because exactly 5000 computers failed. Relatively to the total numbers of companies and computers, these numbers are remarkably low.

The text seems quite incoherent. However, if cumulativity beyond islands were possible, it should have been OK, stressing the small number of companies that went bankrupt because a computer failed and the small number of computers that were involved in these bankruptcies. This point suggests that cumulativity, unlike codistributivity, is sensitive to island constraints. Thus, whatever mechanism captures cumulative quantification cannot capture the whole range of codistributivity phenomena.

Second, any attempt to reduce codistributivity with plural definites to cumulative quantification that is irreducible to vagueness should provide an account of the distribution of the latter. Following Landman (and ultimately Scha) let me hypothesize that such cases of cumulative quantification are restricted to (singular or plural) *weak* noun phrases (=those NPs that are allowed in *there* sentences, cf. Barwise and Cooper (1981); Keenan (1987)). For instance, (67) does not seem to have a reading like (68).

(67) All the Dutch firms used all the American computers.

(68) All the Dutch firms used an American computer and all the American computers were used by a Dutch firm.

In a similar way, sentence (69), but not sentence (70), has a cumulative interpretation.

(69) Exactly one Dutch firm used exactly one American computer.

(70) Every Dutch firm used every American computer.

The non-availability of codistributivity with numeral *def*inites and proper name conjunctions in sections 3.3.2 and 3.3.1 shows further support for this hypothesis. If, as claimed above, codistributivity does not appear with these NPs, then it is unclear how a general process of cumulative quantification can rule codistributivity out in these cases but not with simple plural definites.

3.5 Falsifiability: some potential counter-examples and their account

The proposed treatment of codistributivity is incomplete at too many points. I do not claim to have a theory of dependent definites, vagueness, or even a full syntactic-semantic account of distributivity. No explicit proposal has been made as for how contextual factors can affect dependency (and potentially vagueness). As said above, this puts the present proposal (not unlike competing ones) in a danger of unfalsifiability. By way of recapitulating this section, let me therefore repeat the main claims and explain how they can be falsified. I will give some potential counter-examples and argue that they do not significantly challenge the proposal.

The predictions of the dependency approach can be summarized as follows:

(71) Let DNP_1 be a plural definite that c-commands another DNP_2. In case the two NPs codistribute *and vagueness interference is eliminated*:

1. Replacing DNP_1 by any quantificational NP preserves a ”dependency” effect on DNP_2.
2. Replacing both NPs by *coreferential* proper name conjunctions or numeral definites eliminates the codistributivity effect.[32]

Let us discuss some potential counter-examples. Consider first sentence (72) below, a variation on a felicitous example by Schwarzschild.[33] Compare the status of this sentence with respect to the two figures 5a-b.

(72) The single lines run parallel to the double lines.

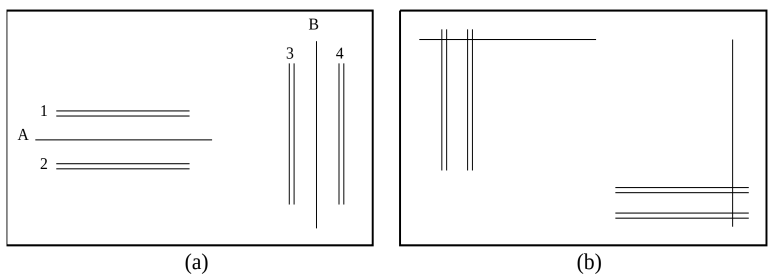

Figure 5: lines

Intuitively, (72) is true in figure 5a and false, or distinctly odd, in figure 5b. This nicely shows the relevance of issues like visual perception to such codistributivity effects: both figures are completely equivalent as far as the *run parallel* relation between lines is concerned. Contrast now (72) with (73).

(73) Every single line runs parallel to the double lines.

[32] In principle, replacing only DNP_2 should have been enough to eliminate dependency. However, if at LF this NP can have scope over DNP_1 then dependency ”in the opposite direction” may be possible. In this situation the complex matters of weak crossover brought up by Chierchia interfere, as mentioned in note 20.

[33] The reason why I reverse the subject-object relations in Schwarzschild’s original example will become clear in the discussion of examples (77)-(78) below.

This sentence is much worse than (72) in figure 5a.[34] This may not seem a problem for the present proposal, as sentence (72) might in principle be a case of vagueness, without any dependency. However, compare sentence (72) in the situation of figure 5a with the following sentences in the same situation.

(74) Lines A and B run parallel to lines 1, 2, 3 and 4.

(75) The (two) single lines run parallel to the four double lines.

Sentences (74) and (75) are much less acceptable than (72) in the given situation. If the acceptability of (72) is a case of vagueness, it remains a mystery why (74) and (75) are not vague in the same way. Similarly, Schwarzschild's polyadic analysis of codistributivity in (72) fails to account for this contrast. However, sentence (72) may in fact be a case of dependency different than the dependency of the object on the subject in sentence (73). Let us hypothesize that the acceptability of sentence (72) in the given situation is due to dependency of both definites on an *implicit quantifier*, made explicit in the following sentence.

(76) <u>In each part of figure 5a</u>, the single lines run parallel to the double lines.

In (76), the two definites may be understood as dependent on the underlined quantifier. If the a similar quantifier is implicit in (72), then we naturally account for the contrast in the acceptability of this sentence between figures 5a and 5b, as well as the contrast between sentences (72) and (74)-(75). More on the postulation of dependency on implicit quantifiers will be said in section 4.

Consider another potential problem. Contrast the status of (77) and (78) with respect to figure 6.

(77) The circles are connected to the triangles by a dashed line.

(78) Every circle is connected to the triangles by a dashed line.

Here, even in a linguistic context similar to (34a) (e.g. *every circle contains a triangle*), (78) is bad. Why does (77) nevertheless show a non-vagueness codistributivity effect? The issue at stake here is sometimes called *dependent plurals*. As noted already by Chomsky (1975),[35] syntactic plural number does not always entail "semantic plurality". The examples in (79) can be true even in common situations where no unicycle has more than one wheel. The sentences in (80), by contrast, are all false or distinctly odd in such situations.

[34] As usual, in a context like the following one, which emphasizes the dependency between the single lines and the double lines in figure 5a, sentence (73) ameliorates.

(i) Look at figure 5a. In this figure, every single line is adjacent to two double lines...

[35] See also Roberts (1987:sec.3.5) for a detailed discussion.

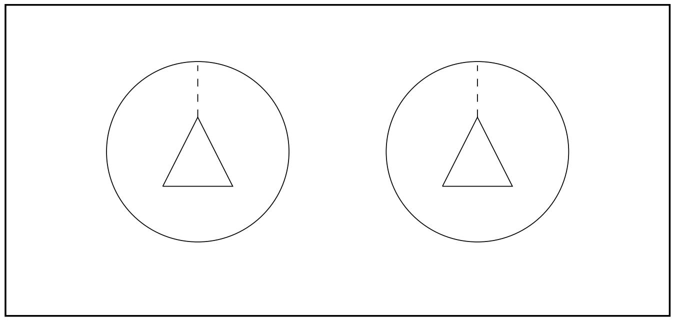

Figure 6: circles and triangles

(79) ϕ/all/the unicycles have wheels.

(80) a/every/the unicycle has wheels.

The same effect, I argue, is responsible for the contrast between sentences (77) and (78). The function T standing for *the triangles* does not necessarily give sets with more than one member. The plurality of the object in (77) does not carry a semantic plurality implication, as it is the case in (79). In a way, the morphologically plural subject licenses in both cases ”semantic singularity” of the object although the latter is morphologically plural. In (78) and in (80) the subject is singular, hence no ”plural dependency” appears. What is the origin for these effects is of course a question that begs an answer, but it is independent of our main problem. As further evidence for that, note that replacing the subject in (78) by *all circles* or *both circles* makes the sentence be true in figure 6 like sentence (77). A similar point was mentioned in Kroch (1974:p.221).

Another potential problem for the present approach is that sentence (81), uttered in context (17), is as good as (19), assuming the total number of soldiers is two and the total numbers of targets is four. This is no real challenge, however, because in this particular case also vagueness can interfere and the present proposal explicitly avoids responsibility as for the effects that may be relevant in such cases. Also the polyadic approach does not explain such factors (cf. (72) vs. (74) or (75)).

(81) The two soldiers hit the four targets.

There are also some potential counter-examples to the claims that proper name conjunctions never show codistributivity effects. Consider for instance a variation on a sentence from Sternefeld (1998).[36]

(82) John and Bill had relations with Mary, Sue and Ann.

[36]The original example involves two binary coordinations, which, as claimed in subsection 3.3, may be subject to interfering *respectively* effects.

This sentence is true if John had relations with Mary and Bill had relations with Sue and Ann. I would like to argue that this may again be a vagueness effect. Sentence (82) should be modeled along the lines of (83).

(83) $\exists R[|R| \geq 2 \wedge R \subseteq \mathbf{relation'} \wedge \mathbf{have'}(\{\mathbf{j'}, \mathbf{b'}\}, \{\mathbf{m'}, \mathbf{s'}, \mathbf{a'}\}, R)]$

This statement may well show a codistributivity effect due to the plural predication: it asserts a relation among three groups. Any alternative analysis of bare plurals like *relations* has the same property. Importantly, replacing the bare plural by a singular indefinite makes the codistributivity effect diminish, if not disappear:

(84) John and Bill had an affair with Mary, Sue and Ann.

Suppose John had an affair with Mary and Bill had an affair with Sue and Ann. Sentence (84) is much stranger than (82) in this context. A similar effect in a less abstract example is the contrast in (85), relative to figure 7.

(85) Points A and B are connected to points 1, 2 and 3 by arrows/#an arrow.

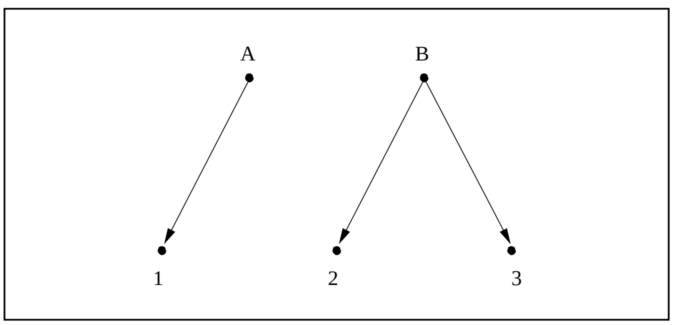

Figure 7: points and arrows

The coherence of the plural *arrows* is expected with reading (86) due to vagueness. No vagueness is possible in this respect with (87), which stands for the meaning of (85) with the singular *arrow*.

(86) $\exists X[|X| \geq 2 \wedge X \subseteq \mathbf{arrow'} \wedge \mathbf{connected'}(\{A, B\}, \{1, 2, 3\}, X)]$

(87) $\exists x[\mathbf{arrow'}(x) \wedge \mathbf{connected'}(\{A, B\}, \{1, 2, 3\}, x)]$

One additional potentially problematic case, pointed out in Winter (1996b), is the following contrast. Sentence (88) is rather good in the situation represented by figure 8. However, sentence (89) is quite impossible in this situation.

(88) Mary and Sue gave birth to John, Bill and George.

(89) Mary and Sue saw John, Bill and George.

In both cases vagueness may play a role. In Winter (1996b) I proposed that the contrast is expected by a generalization of the *Strongest Meaning Hypothesis* of Dalrymple et al. (1994), which can be considered as a first systematic study into certain vagueness effects with reciprocals and distributive predicates.

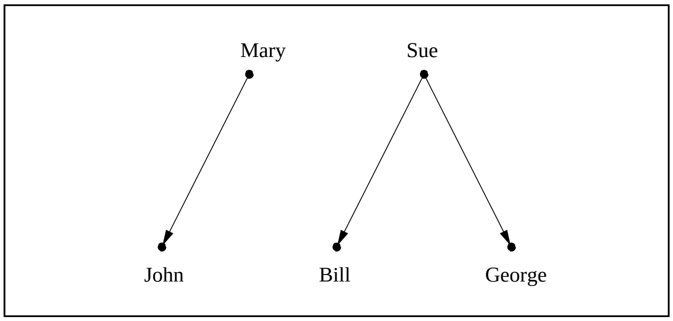

Figure 8: *give birth* vs. *see*

Another potential problem (thanks to Irene Heim, p.c.) comes from sentence (90), contrasted with (91).

(90) The boys gave girls one through fifteen a flower.

(91) The boys each gave girls one through fifteen a flower.

While sentence (90), like (35), allows a codistributive interpretation, sentence (91) does not. Since the noun phrase *girls one through fifteen* in (90) is ”referential”, and cannot possibly depend on the subject, this may seem to be a case where codistributivity is irreducible to neither vagueness nor dependency. However, codistributivity in (90) may result on dependency of the definite subject *the boys* on the object *girls one through fifteen* under a ”weak crossover” construal at LF, where the object takes scope over the subject. A piece of evidence for this possibility is the following sentence, where also the subject in (90) is replaced by a referential NP.

(92) Boys one through four/John, Bill, George and Sam gave girls one through fifteen a flower.

In this example, with two referential NPs, there is no dependent construal, even when taking inverse scope derivations into account. Expectedly, the codistributivity effect disappears.

4 Dependency and non-atomic distributivity

In section 3 it was shown that codistributivity effects that are irreducible to vagueness are restricted to plural definites in contexts where they can be interpreted as referentially dependent. The conclusion was that a unary distributivity operator can describe codistributivity effects better than alternatives involving polyadic operators. A related question about distributivity operators concerns their *atomicity*: whether they range over atoms or over arbitrary pluralities. The following example, after Gillon (1987), was argued to involve distributive quantification that is not strictly atomic.

(93) The composers wrote operas.

Consider a situation $\mathbf{S}$, where the composers are John, Bill and George. John and Bill wrote one opera together, and so did Bill and George. No other operas were written. Sentence (93) is intuitively true in $\mathbf{S}$.

Many works directly conclude from this fact that atomic distributivity is inadequate: (93) can be true in situations like **S** where no composer wrote any opera on his own, nor did the composers ever cooperate as one team in writing operas. Instead of atomic distributivity, a popular view is to extend the distributivity mechanism to quantify over arbitrary sub-groups of the plural individual argument. Using Schwarzschild's cover mechanism, for instance, the meaning of sentence (93) can be modeled as in (94) below.

(94) $Cov(M) = \{\{\mathbf{j}, \mathbf{b}\}, \{\mathbf{b}, \mathbf{g}\}\}$

$\forall X \in Cov(M)\, \exists Y \subseteq \mathbf{opera'}\, [\mathbf{write'}(X, Y)]$

Although such non-atomic distribution may solve the apparent problem for atomic distributivity in (93), it causes overgeneration in many cases (see Lasersohn (1989);Lasersohn (1995)), For instance, consider the unacceptability of the following sentences.

(95) #The three men are a nice couple.

(96) #These three men have an even number of noses.

(97) #Points A,B and C in figure 9 are connected by a dashed line segment.

A non-atomic approach to distributivity expects each of these sentences to be contingent: the sentences are verified using the same kind of covers used in the analysis of (93). The atomic treatment correctly expects the sentences to be false. For instance, given that any couple includes exactly two members, sentence (95) must be false under both the collective and the distributive construals. Given that most people have exactly one nose, sentence (96) must be false both collectively and distributively. Given that

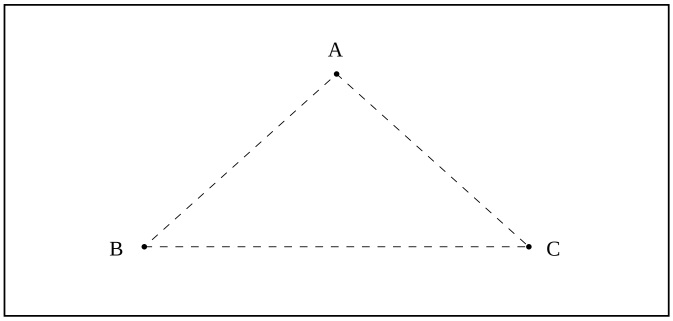

Figure 9: three points and dashed line segments

a line segment connects no more (and no less) than two points, sentence (9) must be false under the collective reading (as well as the distributive one).

Superficially looking, both the atomic and the non-atomic treatments seem inadequate: the first undergenerates in (93), whereas the latter overgenerates in (95)-(97). But does the atomic view indeed fail in rendering (93) true in the aforementioned situation **S**? Using an atomic distributor we get two readings for (93). The criticism of this treatment is often based on the assumption that these readings can be correctly paraphrased as follows.

(98) Every composer wrote operas on his own.

(99) There are some operas that the composers wrote together as one group.

If this assumption is correct then we have a problem: unlike (93), both (98) and (99) are false in $\mathbf{S}$. However, the assumption ignores two points:

1. As for the distributive candidate for paraphrasing (93), the issue of ”dependent plurals” has to be taken into account. When a plural like *operas* appears as in (98), without a plural ”antecedent”, it carries the entailment/implicature of plural semantic number. We know, however, that this is not the case when a plural antecedent appears as in (93) (cf. (79)). The ”atomic” distributive reading is in fact equivalent to the following sentence.

   (100) Every composer wrote *an opera*.

2. The collective reading for (93) is plausibly:

   $$\exists X[|X| \geq n \wedge X \subseteq \mathbf{opera'} \wedge \mathbf{wrote'}(M, X)]$$

   with $n \geq 1$ and an entailment/implicature $n = 2$.

   Such a vague reading does not necessarily carry a ”group collaboration” entailment. Thus, (99) does not paraphrase it adequately. A more appropriate paraphrase is the following:

(101) There are operas that the composers wrote.

This sentence is true in **S**. Consequently, the collective reading *is* true after all in situation **S**.[37]

Thus, (93) can be a real challenge to the atomic approach to distributivity only if it can be true when both (100) and (101) are false. This is not the case.

To further exemplify these qualms, consider the following variation:[38]

(102) The composers wrote an opera.

This sentence is much harder to accept as true in situation **S**. If it has a reading that is true in this situation to begin with, then I expect any speaker who accepts it to accept also one of the following sentences as true in **S**.

(103) Every composer wrote an opera.

(104) There is an opera that the composers wrote.

These sentences correctly paraphrase the two readings generated for (102) in the ”atomic” distributivity assumption. Both are plausibly false in **S**, similarly to (102). Of course, a non-atomic approach to distributivity like Gillon's or Schwarzschild's incorrectly predicts sentences (93) and (102) to be equally acceptable in situation **S**.

As it is the case in (85), a less abstract example is helpful. Consider for instance the contrast between the sentences in (105) with respect to the situation in figure 10.

(105) a. The children are holding wheels.

b. # The children are holding a wheel.

While sentence (105a) is true in figure 10, sentence (105b) is false or highly strange.[39] Again, this is expected if the collective reading is responsible for the truth of (105a) in this situation, as the same contrast appears between the following sentences.

(106) a. There are wheels that the children are holding.

b. There is a wheel that the children are holding.

The non-atomic view expects no contrast between (105a) and (105b).

So far, we have only seen examples where non-atomic distributivity can be reduced to vagueness. However, another interesting challenge for atomic distribution is given by Schwarzschild (1996). Consider sentence (107) below in the same context provided for sentence (93) above.

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[37] The reply to Gillon (1987) in Lasersohn (1989) embodies a meaning postulate version of this idea.

[38] A similar point is made in Lønning (1991).

[39] To the extent that it is possible in this situation, I expect any speaker that accepts it to accept also the sentence *every child is holding a wheel.*

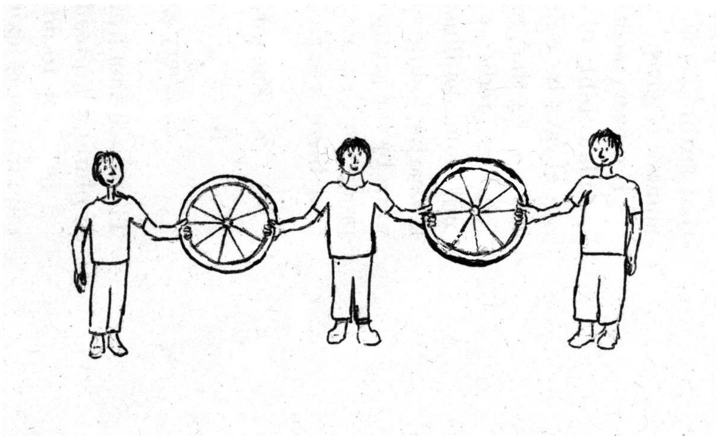

Figure 10: children and wheels

(107) The composers earned exactly \$5000 per opera.

Assume in addition that for each opera an amount of \$5000 was paid to the two composers who wrote it as their shared pay. The sentence is intuitively true. I think that the felicity of this example in this situation may serve as a clue for the origin of some other apparent cases of non-atomic distributivity. Consider for instance the following variation on (107).

(108) For each opera, the composers earned exactly \$5000.

In this case, the dependency line has no problem to account for the apparent non-atomic effect. Clearly, the noun phrase *the composers* may depend on the opera being quantified over by the phrase *each opera*. A similar dependency relation may be present between the definite in (107) and the phrase *per opera*. Moreover, as noted earlier in this paper concerning sentence (72), definites may depend on quantifiers that are not explicitly stated in the sentence. For instance, consider the following text.

(109) In each of the years 2000-2010, one grand opera will be commissioned by the municipal opera house. Each year, two composers that will be chosen by a special committee will be asked to collaborate in writing a new opera. *The selected composers will earn \$5000*.

In this case, the dependency of the composers under discussion on the relevant opera or year of commission is understood, even though no phrase like *for each opera* or *every year* is present in the last sentence of the discourse. An analysis that ignores this dependency may take the phrase *the selected composers* in (109) to denote the whole set of selected composers. Only under such an implausible analysis can the italicized sentence in (109) be considered as evidence for non-atomic distributivity.

Let us formulate the following hypothesis about non-atomic distribution and dependent definites.

(110) **Non-atomicity as dependency**: In each case where non-atomic distribution is irreducible to vagueness, it is a case of a definite NP (or another anaphor) dependent on a (possibly implicit) quantifier.

As further support this hypothesis, consider the situation depicted in figure 11. Consider

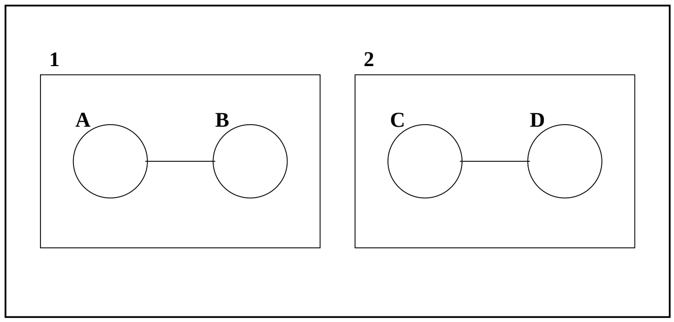

Figure 11: non-atomicity as dependency

the sentences in (111a-c) under the given context.

(111) In figure 11 there are two rectangles. Each rectangle contains two circles.

  a. The (two) circles are connected by a line.

  b. #Circles A, B C and D are connected by a line.

  c. #The four circles are connected by a line.

While sentence (111a) is acceptable in the given context, sentences (111b) and (111b) are not. This is expected under the dependency analysis of the definite *the circles* in (111a) but not under the non-atomic distribution analysis, which expects the three sentences in (111) to be equally acceptable.

Once the context creates dependent definites in this way, distributivity may seem non-atomic. However, a replacement of the definite by a non-dependent element shows that non-atomicity is only apparent. The same holds for more complex cases, where pseudo-polyadic distributivity interacts with pseudo-non-atomic distributivity. Such a case was mentioned at the end of subsection 3.2, considering sentence (35), restated below as (112), in situation (113).

(112) The boys gave the girls a flower. (=(35))

(113) The boys are John, Bill and George. The girls are Mary, Sue, Ann and Ruth. John gave Mary and Sue a flower. Bill and George gave Ann and Ruth a flower, <u>as a shared present from both of them</u>.

In a context where John met Mary and Sue, and Bill and George met Ann and Ruth, sentence (112) can be interpreted as true in situation (113). However, this may happen due to dependency of the definite *the boys* on an implicit quantifier such as *in each meeting*, and not due to any non-atomic/polyadic distributivity operator. [40]

5 The remaining motivation for distributivity operators

In the preceding discussion it was observed that the referential dependency of definites on implicit quantifiers can be used to account for all known cases of polyadic or non-atomic distributivity. We may even try to account for simpler *unary-atomic* effects in a similar way. Reconsider for instance sentence (4a), restated below.

(114) The girls are wearing a dress.

When the subject *the girls* is interpreted as dependent on an implicit quantifier like *in each room*, we may get more than one dress for the whole set of girls, according to the way the girls are located in the rooms. Especially, if in each room there is a single girl, we may get one dress per girl as intuitively desired, assuming that the context makes the dependency of the definite salient.

While this analysis of the atomic-unary distributivity in (114) is certainly an available option in some (probably marked) contexts, it is highly unlikely to cover all cases of distributivity. Consider for instance the following examples.

(115) The three girls are wearing a dress.

(116) The girls met and drank a glass of beer.

These sentences illustrate quantificational distributivity effects that cannot be accounted for using anaphoric dependency. In sentence (115), distribution is similar to that in (114), but the numeral prevents a dependency analysis, as explained earlier in this paper. Sentence (116) is the kind of examples that were given in the literature (cf. Lasersohn (1995)) for distributivity effects which cannot be analyzed at the NP level. Distributivity in this example appears only with the second VP conjunct, but not with the first. Hence, it cannot be the reference of the subject that is responsible for the

[40] Another motivation for Schwarzschild (1996) to adopt a cover analysis comes from examples like *the authors and the athletes are outnumbered by the men*, where his ”union” approach to conjunction seems to fail without a non-atomic mechanism of distributivity. I doubt whether such cases are any challenge even to the particular assumptions that Schwarzschild adopts. The ambiguity analyses of conjunction in Hoeksema (1983) and Hoeksema (1988), which are endorsed by Schwarzschild (1996:p.23), can capture such effects using the ”intersective” (boolean) reading of the conjunction. The same holds of the uniformly boolean treatment of conjunction in Winter (1996a) and Winter (1998).

It is important not to confuse effects of distributivity that can be captured by boolean NP coordination with ”genuine” distributivity effects as in (4a).

distributivity effect, as a dependency analysis would require. For instance, we may conclude that even with plural definites it is impossible to account for all distributivity effects using dependency considerations alone.[41]

6 Conclusion

The variety of semantic mechanisms that were proposed in the literature for the analysis of plurals has deepened our understanding of the problems in this domain. At the same time, this variety of theories seems to have resulted from lack of satisfying knowledge about the relationships between plurality and other semantic phenomena of natural language. In this paper I proposed that two general properties of reference in natural language – its *vagueness* and its extensive use of *anaphora* – are responsible for some of the trickiest phenomena in the semantics of plurals. Vague reference is highly relevant for the study of plurals because in most theories, the properties of plural individuals can be arbitrarily independent of the properties of the singular individuals that constitute them. Thus, the semantic properties of the plural noun phrase *Mary and John* are different from the properties of its conjuncts, in much the same way as the properties of *Mary* are distinct from the properties of *Mary's thumb*. Also the anaphoric/dependent use of definites is an effect that has little to do with the semantics of plurals proper, but nevertheless it was argued to have important consequences for the analysis of plurals. Since the reference of definites, like the reference of other anaphors, may be dependent on the semantics of other elements, the behavior of plural definites often says very little about the behavior of plurals in general. It was shown that some of the notorious polyadic or non-atomic effects of distributivity are restricted to plural definites and do not appear with other simple plurals. Therefore, it was claimed that the dependent use of definites, and not a polyadic or non-atomic formulation of distributivity operations, is the proper account for these effects. When confounding effects such as vagueness or dependency are carefully teased apart, a relatively simple treatment of plurality can be maintained.

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[41]Other NPs besides definites also show distributivity effects that are problematic for any account of distributivity that does not involve covert operators. For instance, replacing the definite *the girls* in sentence (116) by a conjunction like *Mary, Sue and Ann* or an indefinite like *three girls* preserves a distributivity effect that cannot originate within the NP, and hence is likely to be a result of a covert distributivity operator at the VP level.

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