Readings of Plurals and Common Ground

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Abstract. This paper asks two questions: (i) In an ambiguous context, what is the interpretation of a sentence like *The men wrote musicals*? (ii) How can we succinctly characterize the differences between readings that an a sentence has in an ambiguous context, versus readings made available in a specialized context, and those available only because of shared knowledge. While these questions have received much attention, e.g. [1], [9], [10], [11], [20], [21], [22], [23], [24], [26] i.a., the number of readings such a sentence has in an ambiguous context remains controversial, as is the availability of additional readings, and the mean by which speakers become attuned to readings in a given context. To answer the first question we conducted an online study where participants evaluated the truth value of sentences designed to test the meaning of those like *The men wrote musicals*. Results suggest that such sentences get a double cover interpretation (i.e. an interpretation in terms of a relation between sets of individuals, rather than a relation strictly between atomic individuals) in an ambiguous context. We couch these results and the discussion on the availability of other readings in terms of a bipartite Common Ground, where available readings are in the Immediate Common Ground, and other readings can be made available via knowledge in the General Common Ground, thereby answering the second question.

Keywords: Plurals · Salience · Common Ground · Covers · Collectivity · Distributivity · Cumulativity.

1 Introduction

The interpretation of sentences with plural nouns like (1) is a controversial topic.

(1) The men wrote musicals.

For example, Gillon [9–11] argues that plurals are ambiguous, rather than vague or indeterminate, in respect to readings that correspond to minimal covers of the plural noun phrase. Gillon [9] defines a minimal cover as a set that (i) is a subset of the power-set of a set being covered, (ii) contains all of the same individuals as the set being covered, and (iii) contains no set that is a subset of another. This explains why (1) is true of Richard Rodgers, Oscar Hammerstein, and Lorenz Hart, though the men never wrote musicals individually or as a trio, rather Rodgers wrote musicals with Hammerstein, and he also wrote musicals with Hart. Lasersohn [21, 23], however, argues that certain cover readings are

never available in certain cases, and that an approach in which plural predicates are ambiguous between collective and distributive interpretations is more sound. Subsequent analyses of plural predicates argue for an additional reading, namely a cumulative reading in which covers of the plural predicates are not specified [1], [20], [26].

The matter of what readings are available a particular time is discussed at least as a pragmatic issue separate from the semantic question of what readings such sentences can possibly have. Gillon [11, 10] assumes that both the beliefs and expectations of interlocutors and the context shape what readings are available. Schwarzschild [24] argues that certain readings must be explicitly mentioned or otherwise salient because of non-linguistic discourse in order to be available. Sternfeld [26] argues that we choose particular readings in effort to make sentences true. In addition to these positions, the question is left open as to the ways in which cognitive mechanisms shape the available readings in a given context.

In this paper, we introduce empirical data from a truth-value judgment task and motivate a new analysis of plural predicates, namely that plural predicates have a double cover interpretation in an ambiguous context—(i.e. an interpretation in terms of a relation between sets of individuals, rather than a relation strictly between atomic individuals or specific sums thereof)—rather than being ambiguous between two or more interpretations. Additionally we specify what it means for readings to be available in a given context by building on the notion of Common Ground [25], and following Krifka [18], we partition Common Ground into parts, namely Intermediate and General Common Ground, also argued for by Berio et al. [2].

2 Background

This paper is focused on sentences like (2), in which there are two plural NPs in a transitive construction that could have a collective, distributive, or any other cover reading.

(2) Alex, Billy, and Charlie wrote songs.

The collective reading of (2) is such that Alex, Billy, and Charlie all co-wrote the same songs, while a the distributive reading is such that Alex, Billy, and Charlie each wrote their own songs. There are over 100 possible readings of (2), called *cover readings* [9], which are such that some combination of Alex, Billy, and Charlie wrote songs as individuals and/or as groups. For example, one cover of (2) is the reading in which Alex wrote songs individually and with Charlie, while Billy also wrote songs both individually and with Charlie $(a, a \sqcup c, b, b \sqcup c)$. More formally, a cover is a subset of the closure under sum of the atoms a set, and the atoms of the supremum of the subset is equal to the set being covered (where atoms are assumed as countable individuals).

(3) A covers B iff $A \subseteq {}^*(AT(B)) \wedge AT(\sqcup A) = B$

Note that collective and distributive readings are two particular cover readings. In this paper, cover readings other than collective and distributive readings are referred to as *intermediate cover readings*.

In addition to cover readings, there is a weaker reading called the cumulative reading [26], [1], [20]. The cumulative reading of a sentence like (4) is one in which three children and five songs were involved in some writing, but it is entirely unclear with respect to which cover of the three children wrote which cover of the songs. In Sternfeld [26], the cumulative reading arises from the ** operation from [19], defined in (5) and results in the logical form in (6).

(4) Three children wrote five songs.

(5) For any two-place relation R, let $^{**}R$ be the smallest relation such that $R \subseteq {}^{*}R$, and
if $\langle a, b\rangle \in {}^{**}R$ and $\langle c, d\rangle \in {}^{**}R$, then $\langle a \oplus c, b \oplus d\rangle \in {}^{**}R$ [26, p. 304]

(6) $(\exists X)(\mathbf{three}(X) \wedge {}^{*}\mathbf{man}(X) \wedge (\exists Y)(\mathbf{five}(Y) \wedge {}^{*}\mathbf{songs}(Y) \wedge \langle X, Y\rangle \in {}^{**}\lambda xy[\mathbf{write}(x, y)]))$

Sternfeld [26] analyzes sentences like (4) as having a single logical form that automatically generates different readings, including collective, cumulative, and distributive.

In addition to Sternfeld's [26] analysis, there have been many analyses of sentences with collective/distributive ambiguity, for example [1], [9], [10], [11], [20], [21], [22], [23], [24], and there is no consensus on the number of readings available upon the interpretation of sentences like (2) or (4). Analyses can be categorized according to how many readings a sentence with collective/distributive ambiguity might have, e.g. two or many. Though this categorization does not capture the subtleties that make each theory different from one another, it highlights the underlying point: the interpretation of sentences like (2) remains a matter of debate. While all agree that the sentences in question can have many logically possible readings, two open questions remain: (i) What is the interpretation of such sentences an ambiguous context? By this we mean, in an ambiguous context, what is it that native speakers of English understand such sentences to mean, and how many readings are part of this meaning? (ii) In a context where such a sentence is ambiguous between two or more readings, how is it that these readings are "available" (or in terms of Schwarzschild [24], "contextually salient"), and what does it mean for certain cover readings to never be available as argued by Lasersohn [21],[23]?

2.1 Previous Analyses

Two-reading analyses. Two-reading analyses include Lasersohn [23], who argues that sentences with both collective and distributive readings are straightforward examples of ambiguity. He argues for this analysis by showing that it must be the case that both collective and distributive readings are available for certain pairs of sentences to be true. (7-a) and (7-b) are one such pair which can

both be true at the same time only if both sentences are ambiguous between collective and distributive readings.

(7) a. John and Mary earned exactly $10,000.
b. John and Mary earned exactly $5,000. [23, p. 131]

In other words, (7-a) and (7-b) can both be true because the collective reading of (7-a) has the same truth conditions as the distributive reading of (7-b). Lasersohn [23] argues that, without assuming these two readings are straightforwardly available, (7-a) and (7-b) cannot both be true at the same time, which is not the case.

Lasersohn [21] argues multi-reading analyses—e.g. Gillon [9]–claiming that certain minimal cover readings are never available. For example, under Gillon's [9] analysis, (8) is incorrectly predicted to be a true statement when John, Mary, and Bill are teaching assistants (TAs) who each made exactly $7,000 every time they occurred as a member of co-TA teams: {John and Mary}, and {John and Bill}. In other words, each pair of John, Mary, and Bill collectively earned exactly $14,000, so (8) should be true but is not according to Lasersohn [21].

(8) The TAs were paid exactly $14,000 last year. [21, p. 131]

Because Lasersohn [21] assumes that (8) is false in a situation where the pairs {John and Mary}, and {John and Bill} each made exactly $14,000, a multi-reading analysis that includes minimal covers like Gillon's [9], [10], [11] is untenable. This argument, in addition to the argument that sentences like (7-a) and (7-b) must have two readings in order to both be true, is why Lasersohn [21] analyzes such sentences as straightforwardly ambiguous between only collective and distributive readings.

Many-reading analyses. Many-reading analyses include Gillon [9], [11], and [10], Sternfeld [26], Beck and Sauerland [1], and Landman [20]. In Gillon's early work, [9], he argues that sentences like (2) are ambiguous in respect to their truth conditions, which is a set of minimal covers—i.e. sets of subsets of pluralities, in which none of the subsets overlap with the union of the others, and the union of all subsets is equal to the plurality itself (9).

(9) A minimally covers B iff A covers B $\wedge \neg\exists$X(X $\subseteq$ A $\wedge \bigcup$(A-X) covers B)

In other words, (2) has eight possible interpretations which correspond to the minimal covers of the subject NP. As discussed above, if we are discussing Rodgers, Hammerstein, and Hart, the sentence, *The men wrote musicals*, is true under the reading where Rogers and Hammerstein wrote musicals together as did Rogers and Hart, though it is false under both distributive and collective readings.

More recently, Gillon [10] has argued that extra-grammatical conditions constrain the possible readings of a given plurality. He insists that context can make available intermediate minimal cover readings—i.e. minimal cover readings

other than collective and distributive. Gillon [11] gives (10-a) as an example of a context that makes intermediate cover interpretations available.

(10) a. A chemistry department has two teaching assistants for each of its courses, one for the recitation section and one for the lab section. The department has more than two teaching assistants and it has set aside $14,000 for each course with teaching assistants. The total amount of money disbursed for them, then is greater than $14,000. At the same time, since the workload for teaching a course's section can vary from one section to another, the department permits each team of assistants for a course to decide for itself how to divide the $14,000 the team is to receive.

b. The T.A.'s were paid their $14,000 last year. [11, p. 483].

While (10-a) does not explicitly point to which minimal cover is true, it nevertheless gives the context necessary to know that distributive or collective readings of (10-b) are not true, and an intermediate cover reading is necessary. With (10-a) as context, (10-b) is straightforwardly true, according to Gillon [11]. In addition to explicit contextual information, Gillon [11] assumes that the beliefs and expectations of interlocutors have a role in determining the available readings of sentences. Gillon [11] argues that a sentence like *The man surrounded the town* is grammatical and true in a novel like *Gulliver's Travels* where the readers know that Gulliver is such a size that he can indeed surround an entire town. For Gillon [11], it is extra-grammatical information such as this that restrict the possible readings.

Sternfeld [26], Beck and Sauerland [1], and Landman [20] each provide different multi-reading analyses than Gillon, each arguing for the existence of the cumulative interpretation [26], [1], [20].With the addition of the cumulative interpretation, *The men wrote musicals* is not only true of the intermediate cover that specifies the pairs {Rogers and Hammerstein} and {Rogers and Hart}, but it is also true of the weaker, cumulative reading in which neither the cover of Rodgers, Hammerstein, and Hart nor the cover of musicals is specified with respect to the writing. Sternfeld [26] also argues that an interlocutor's desire to find a true reading of a particular sentence determines which reading a sentence is chosen to have in a particular interpretation, therefore it is the truth conditions of a sentence that dictate the readings in a particular context.

Hybrid analyses. Schwarzschild [24] argues for an analysis that incorporates elements of both two- and a many-reading analysis. In his context based analysis, he analyzes plural predicates as having a single meaning that can be indexed to any cover reading in the appropriate context. According to Schwarzschild, [24], "whether or not a certain intermediate reading is available seems to have to do with the context not with the semantics of particular lexical items" (p. 66). He therefore proposes the following generalization to account for cover readings:

(11) [$_S$NP$_{plural}$ VP] is true in some context Q iff there is a cover C of the plurality P denoted by NP which is salient in Q and VP is true for every element in C.

While Schwarzschild [24] does not explicitly argue for cumulative readings, Sternfeld [26] uses definitions such as (11) as the formulation of cumulative readings. Cumulative readings are therefore built into Schwarzschild's [24] analysis although never evoked.

The generalization for distributive readings is formalized in (12), where Part is the one place distributivity operator and Cov is free variable over sets of sets of the domain of quantification, the value of which is determined by the linguistic and non-linguistic context.

(12) $x \in \|Part(Cov)(\alpha)\|$if and only if $\forall y[(y \in \|Cov\| \wedge y \subseteq x) \rightarrow y \in \|\alpha\|]$ [24, p. 71]

Schwarzschild [24] specifies the translation rule in (13) which means that a plural predicate is indexed to a particular cover reading.

(13) Plural VP rule:
If α is a singular VP with translation α', then for any index i, Part(Cov$_i$)(α') is a translation for the corresponding plural VP.

These rules allow any cover reading to be indexed given the right context. (14-a), for example, therefore has the logical form in (14-b), where the two-place Part operation distributes the predicate to the subsets of the indexed cover(s), Cov$_i$.

(14) a. The musicians wrote songs.
b. (Part(Cov$_i$)(wrote'))(songs')(the-musicians')

Schwarzschild [24] concludes that the absence or presence of a given cover interpretation depends, to some extent, on the same sorts of things that other pragmatic phenomena like anaphoric reference depend on, like salience. However, in an ambiguous context, collective and distributive readings are made salient by the plural noun phrase itself. So, while plural predicates have a single interpretation, is in some sense a place-holder for one or more indexed cover readings.

The discussion of salience in Schwarzschild [24] builds on work on anaphoric reference with pronouns. He notes that, for pronouns, it is necessary for the referent to be explicitly mentioned in order to be accessible, though this is not a sufficient condition. These points are respectively reflected in (15) and (16).

(15) Nine of the ten balls are in the bag. It's under the couch. [24, p. 94]

(16) The boys and the girls entered the room (separately). They were wearing hats and they were wearing skirts. [24, p. 95]

In (15), the first sentence indicates there is a ball not in the bag, though because this ball is not explicitly mentioned, the follow-up sentence seems odd: the referent of *it* is not entirely clear. This is taken to indicate that referents of pronouns must

be explicitly mentioned. In (16), though two groups of children are explicitly mentioned by distinguishing them according to gender, the sequential uses of *they* in the follow-up sentence does not straightforwardly correspond to respective anaphoric reference. This mismatch of explicitly mentioned anaphora is taken to indicate that their explicit mention is not a sufficient condition for anaphoric reference. Schwarzschild [24] extends this analysis to cover readings, arguing that (16) *the boys and the girls* is explicit mention of a cover—the sum of the set denoted by *the boys* and the set denoted by *the girls* covers the implicit NP *the children*—and therefore that the sort of pragmatic and extra-linguistic principles that apply to pronominal anaphoric reference also apply to cover interpretations.

2.2 Availability and Salience

The question that remains, is how can we succinctly characterize the differences between readings that an a sentence has in an ambiguous context, versus readings made available in a specialized context, and those available only because of shared knowledge? Schwarzschild's [24] position on the explicit salience of a cover is stronger than Gillon's [11, 10] less-clear notion of context shaping the domain of quantification. For example, it is not clear if Schwarzschild [24] would agree that the intended minimal cover has been made salient in the context Gillon [11] provides in (10-a). Similarly, Sternfeld's [26] position on the goal of interlocutors to find a true reading is stronger than Gillon's [11, 10] assumption that the beliefs and expectations of interlocutors and shape what readings are available. For example, Sternfeld [26] might (not) argue that an interlocutor does not need the rich context provided in the novel *Gulliver's Travels* to find a true reading of the sentence *The man surrounded the town.* At the same time, there has been no discussion of Lasersohn's [23] position that certain readings are never available, and it is unclear if there is any extent to which such a position is compatible with the others. These potential incompatibilities make clear the fact that there is no straightforward characterization of what it means for a reading to be available in a given context.

Contexts of quantification A related set of questions regards the inquiry about domain quantification and context carried on in the context of Philosophy of Language. In what follows, we will argue that, while that debate adds an interesting perspective to the problem raised by ambiguous sentences with plural predicates, it does not exhaust all the pending questions.

A relevant analysis of context and quantifiers is that by Bianchii [3], where the debate about intentional and objective context is connected to the conditions for determining the quantification debate. Bianchi [3] follows the analysis of Gauker [7] in distinguishing between how theories predict a restriction of the domain of quantification. These theories fall into one of two classes, those with Intentional Perspective on Context (IPC) and those with Objective Perspective on Context (OPC) [7]. The main intuition underlying IPC (Intentional Perspective on Context), is that the intention of the speaker counts towards determining

the truth conditions of a proposition, thereby, following the direction of the Gricean tradition [12, 13]. OPC (Objective Perspective on Context) argues that the propositional content of the utterance is to be determined by looking at the objective features of the context and that the intention of the speaker is irrelevant for determining the semantic value. As [3] puts it, the debate is connected to the more general question regarding what determines reference in cases, like indexicals and demonstratives, where contextual information has to be taken into account [16], [17].

Gauker [7] argues against IPC with examples like (17), which, in certain contexts, are infelicitous despite the intention of the speaker. The context is the following: Scout and Jo are playing with Jo's marbles in her room. Scout utters

(17) All of the red marbles are mine!

With (17), Scout intends to refer to the marbles that are laying in her own room, under the bed, away from the current communicative situation involving Jo. Gauker [7] uses a similar example to argue against IPC, given the fact that, if the speaker's intention was relevant to determine the propositional content of (17), we would be forced to consider the proposition to be true, even though, according to our intuition, it is more likely to be false; Jo could rightly be upset with Scout, thinking she wants to claim property of her red marbles. Gauker [7] then, openly criticizes IPC because it appeals to intentions and mental representations, arguing that what is relevant for determining the domain of quantification is, instead, the objective context of the utterance–i.e, the relevant states of affair in the world.

Bianchi [3] defends IPC from Gauker's [7] attacks by arguing that IPC does not simply defend a view according to which *any* semantically relevant intention of the speaker related to the communicative situation is relevant for individuating the quantification domain; instead, the only intentions that are to be considered are those made *available* in respect what she calls an *availability constraint*. In other words, an intention that is made available to the addressee, and that therefore is "non arbitrary—that is connected with a particular external context, or a suitable behavior, or else an appropriate co–text, that enable the addressee to determine the referent" [3, p.389]. Such an intention is recognized on the basis of the physical surroundings (or "external" facts), linguistic co-text, and background knowledge.

Pending questions in the analysis. Bianchi's [3] solution, we would argue, captures a relevant issue, namely that there is a plurality of factors involved in determining the relevant proposition expressed by an utterance like (17). With respect to the readings of sentences with plural predicates, following Bianchi [3], the speaker may have a particular reading of the sentence in mind, however, without the speaker making the particular reading explicitly available with (extra-)linguistic information in the context, the particular reading will in no way be available to hearer. In other words, a sufficient condition for making a particular reading available is for the speaker to make it known to the hearer

that a particular reading is intended. Not only does this clarify what it means for a reading to be made contextually salient via (extra-)linguistic information, but it also points to what it means for a reading not to be available, namely that it is not brought into focus by the speaker nor the extra-linguistic information in the context. In this sense, Bianchi points out a relevant fact about the communicative situation above: shared knowledge is relevant to make the communicative context successful. However, her focus is on defining the relevant features of the context that grant the truth conditions and, in this sense, her account does not point to how the sentence is interpreted in the an ambiguous context, all the ways in which the sentence could potentially be understood, or the relation between the semantic content of the sentence and its speakers' interpretation.

3 Main Data

While Bianchi's [3] contribution points out the role of a shared intention in context, the interpretation of a sentence like (2) in an ambiguous context is still unclear. In addition to distributive and collective readings of plural predicates, lexical modifiers like *each* have a distributive effect, and modifiers like *together* have a collectivizing effect [10], [24], [27]. These lexical modifiers can therefore be used to restrict the possible interpretations to distributive, (18-a), or collective, (18-b).

(18) a. Alex and Billie wrote songs individually.
b. Alex and Billie wrote songs together.

If plural predicates like *wrote songs* have all minimal cover readings available as argued by Gillon [9] in his early work, then (2) should be equally ambiguous in respect to the combinations of song-writers listed in (19).

(2) Alex, Billie, and Charlie wrote songs.

(19) a. $a \sqcup b \sqcup c$
b. $a \sqcup c, b \sqcup c$
c. $a \sqcup b, b \sqcup c$
d. $a \sqcup b, a \sqcup c$
e. $c, a \sqcup b$
f. $b, a \sqcup c$
g. $a, b \sqcup c$
h. a, b, c

If all minimal cover readings are equally available, then it should be possible to refer to a subset of the minimal covers by adding lexical modifications. For example, (20-a) is true of a set of minimal covers, and (20-b) is true of a subset of those minimal covers.

(20) a. Alex, Billie, and Charlie went to the music studio. The musicians wrote songs.
b. Alex and Billie didn't write songs individually.

The set of minimal covers that could be true of both (20-a) and (20-b) includes the distributive interpretation and every other cover in which the predicate distributes

to either Alex or Billie individually.[1] The only available interpretations would be those in which Alex and Billie are part of a collective interpretation. The potentially true minimal covers are listed in (21), along with the false minimal covers, which are crossed out.

(21)
a. $a \sqcup b \sqcup c$
b. $a \sqcup c, b \sqcup c$
c. $a \sqcup b, b \sqcup c$
d. $a \sqcup b, a \sqcup c$
e. $c, a \sqcup b$
f. ~~$b, a \sqcup c$~~
g. ~~$a, b \sqcup c$~~
h. ~~a, b, c~~

It is also possible to use modifiers to eliminate collective interpretations for particular individuals. In (22) for example, the use of *together* in (22-b) negates the scenarios in which Alex and Billie are predicated over collectively.

(22)
a. Alex, Billie, and Charlie went to the music studio. The musicians wrote songs.
b. Alex and Billie didn't write songs together.

The set true and false minimal covers for (22-a) and (22-b) are listed in (23)[2].

(23)
a. ~~$a \sqcup b \sqcup c$~~
b. $a \sqcup c, b \sqcup c$
c. ~~$a \sqcup b, b \sqcup c$~~
d. ~~$a \sqcup b, a \sqcup c$~~
e. ~~$c, a \sqcup b$~~
f. $b, a \sqcup c$
g. $a, b \sqcup c$
h. a, b, c

Taking these modifications one step further, only a single minimal cover is available when using both *individually* and *together* in the same sentence. For example, given (24-a) as a context, (24-b) negates all minimal covers in which *wrote songs* gets a collective or distributive interpretation in respect to Alex and Billie.

(24)
a. Alex, Billie, and Charlie went to the music studio. The musicians wrote songs.
b. Alex and Billie didn't write songs individually or together.

Both (24-a) and (24-b) are true if Alex and Charlie wrote songs together and Billie and Charlie also wrote songs together. The true and false minimal covers of these two sentences are listed in (25).

(25)
a. ~~$a \sqcup b \sqcup c$~~
b. $a \sqcup c, b \sqcup c$
c. ~~$a \sqcup b, b \sqcup c$~~
d. ~~$a \sqcup b, a \sqcup c$~~
e. ~~$c, a \sqcup b$~~
f. ~~$b, a \sqcup c$~~
g. ~~$a, b \sqcup c$~~
h. ~~a, b, c~~

[1] While it could be the case that the use of *The musicians* as opposed to the plural pronoun could be taken as an indication that one of Alex, Billie, and Charlie is not a musician, we contend that these sentences still allow for the reading in which Alex, Billie, and Charlie are all musicians.

[2] though $p \sqcup q$ is only a subpart of $p \sqcup q \sqcup r$, this reading is assumed to be canceled via implicature

Experimental Design. An empirical study was designed to test the interpretations of the sets of sentences, like those in (20), (22), and (24). A truth-value-judgment survey was conducted with 32 native English speakers through Prolific.ac. The participants were presented with 45 test items containing a set-up like (24-a) and a follow-up like (24-b). Participants were told to judge whether the follow-up sentence could be true or must be false in respect to the set-up preceding it. While these directions were written above every set of sentences, the options the participants clicked on were simply labeled *True* and *False*. The 45 test items exemplified one of the three conditions in (20), (22), and (24): 15 test follow-up items contained *individually*, 15 contained *together*, and 15 contained both *individually* and *together*. While each set-up contained a subject DP with three individuals, they varied with respect to the names of the individuals and the VP that followed, but all set-up sentences could be interpreted as true of any cover reading. Participants were also asked to judged the truth value of 45 filler items that could be true or must be false depending on their lexical modifiers. The total number of items expected to be true or false was equal.

Because the pairs of sentences were presented to participants in this experimental context, the context is assumed to be ambiguous, and without any indication that particular readings should (not) be available. We therefore take the judgment of the follow-up sentence as indication of what readings are available of the sentences with plural predicates in the set-up in the manner described above with examples (20)– (24). If all of these follow-up sentences are judged to be possibly true, then it could be the case that the plural predicates are straightforwardly ambiguous between all minimal cover interpretations as argued in Gillon's [9], [10]. Second, if (20) and (22) are judged to be possibly true, and (24) is judged to be necessarily false, then plural predicates have distributive and collective readings in an ambiguous context but intermediate cover readings are not available, as argued by Lasersohn [23] and [24]. Alternatively, if all follow-up sentences are judged to be false, then it is the case that only the the cumulative interpretation is available in an ambiguous context, and all other interpretations are derived or indexed.

Results. The results of the study show that there is a significant difference in the way that the truth of sentences with both *individually* and *together* are judged relative to sentences with only one of the two lexical modifiers. Using a binary logistic regression model (lme4 package in R), and the conditions and judgments as arguments, the judgments of test condition with both *individually* and *together* were found to be significantly different ($p < 0.001$) than judgments of the condition in which sentences only contained *together* as a lexical modifier. Sentences that only contained *individually* as a lexical modifier were found to be judged no differently ($p = 0.282$) than those that only contained *together*. These results show that despite the fact that each follow up sentence is true in respect to its preceding context, speakers do not judge sentences in the test condition to be true at the same rate at which they judge sentences in the other conditions to be true.

The average percentage of true and false judgments for sentences in each condition is presented in Figure 1. This graph shows that follow up sentences with

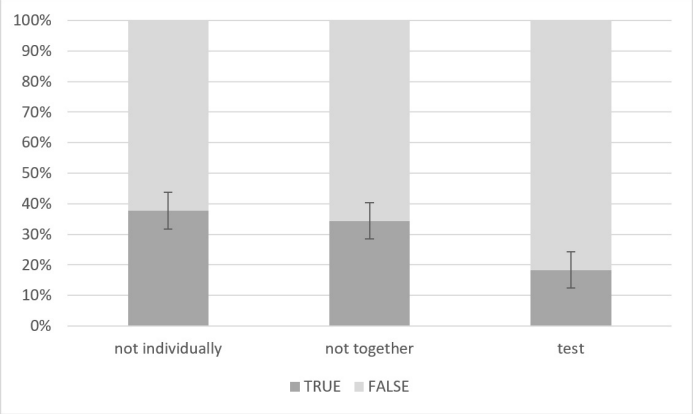

Fig. 1. Average percentage of true and false judgments by condition

only one of the two lexical modifiers are judged as necessarily false a majority of the time, while follow up sentences with both lexical modifiers are judged as false an even larger majority of the time. In other words, negated follow up sentences that restrict the set of true minimal covers with the lexical modifiers *individually* or *together* are generally judged to be false.[3] This is a surprising result given the plural predicates are said to have both collective and distributive readings, yet neither reading seems to be available when the subjects were asked to interpret the possible truth of follow-up sentences. If the collective reading was available, then the follow-up sentences negating the distributive reading should all have been true. Furthermore, if the distributive reading was available, then the follow-up sentences negating the collective reading should have been true.

Discussion. We take the fact that the follow-up sentences were judged to be false to suggest that the plural predicate they follow is not straightforwardly ambiguous between all minimal covers as argued for by Gillon's earlier work [9],[10]. It also does not seem to definitely be the case that, in this context, they are ambiguous between collective and distributive interpretations argued by Lasersohn [23] and Schwarzschild [24][4]. Instead of any of the aforementioned

[3] Although conditions negating just one of the collective and distributive readings respectively are close to 50%, they are significantly different ($p < 0.001$) than an artificial data set in which the same number of items were equally split between true and fall judgments.

[4] Among the possible interpretations of the results, one might argue that the presence of negation in the follow-up sentences might be the reason why the participants judged them to be false—i.e. negative sentences could have made the parsing harder and the judgment more difficult. We thank the anonymous reviewer for the observation.

analyses, the empirical data seems to point toward an analysis in which neither the distributive, collective, nor intermediate cover readings are available readings of such sentences in an ambiguous context.

4 Analysis

The results of the study point towards an analysis in which sentences like *The men wrote songs* have only a weak interpretation in an ambiguous context, but can also index other readings when they are made salient. Because none of the aforementioned analyses argue for such an analysis, we build our analysis on that of Landman [20], whose "double cover interpretation", from which minimal cover interpretations can be derived, expresses a relation between sets of individuals rather than a relation strictly between atomic individuals. This weaker form of a cumulative reading is advantageous because it allows for a more straightforward relationship to intermediate cover readings, which, by nature, involve sets of individuals rather than a relation strictly between atomic individuals.

For Landman [20], intermediate cover interpretations are the result of a special contextual mechanism that weakens the interpretations of verbs. In respect to a plural argument like *the musicians* that denotes three individuals Alex, Billy, and Charlie, or a⊔b⊔c, a minimal cover like Alex and Charlie, and Billie and Charlie (a⊔c,b⊔c in (26)), can be the agent of a plural predicate, e.g. (27)[5], so long as one has a definition of cover roles (28), a definition of covers (29), and a type shifting principle for verbs that allows verbs with plural roles to be turned into cover roles (30).

(26)
$$\{\mathrm{a} \sqcup \mathrm{c}, \mathrm{b} \sqcup \mathrm{c}\} \in {}^*\mathrm{MUSICIAN}$$
$$[\![\text{the musicians}]\!] = \sigma({}^*\mathrm{MUSICIAN}) = \sqcup\{\mathrm{a} \sqcup \mathrm{c}, \mathrm{b} \sqcup \mathrm{c}\} = \mathrm{a} \sqcup \mathrm{b} \sqcup \mathrm{c}$$

(27) $$[\![\textit{The musicians wrote songs}]\!] = \begin{cases} \exists e \in {}^*\mathrm{WRITE}: \\ a \sqcup b \sqcup c = \sigma({}^*\mathrm{MUSICIAN}) \wedge \\ {}^C\mathrm{Ag(e)} = \uparrow(a \sqcup b \sqcup c) \wedge \\ \exists y \in {}^*\mathrm{SONG} \wedge {}^C\mathrm{Th(e)} = \uparrow(y) \end{cases}$$

However, to disambiguate between alternative analyses—two-reading analyses versus many-reading analyses—it was necessary to have a negation in the test sentence since the positive equivalent would not distinguish between the two alternatives. In order to make the control sentences comparable, it was sensible to we kept negation in all the sentences, to avoid a result biased by the presence of negation in the test sentences but not in the control ones. In this way, the difference between response rates for control sentences and test sentences is not attributable to the presence or absence of negation.

[5] AT(d) is the set of atoms below d: if d ∈ D then AT(d) = {a∈AT:a⊒d}

Let R be a thematic role

^{C}R, the cover role based on R,

(28) is the partial function from D_e to D_d defined by:

^{C}R(e) = a iff a ∈ ATOM ∧ ⊔({↓ (d) ∈ SUM: d ∈ AT(*R(e))}) = ↓(a)

undefined otherwise [6, p. 210]

group β is a subgroup of α iff ↓ (β) ⊒ ↓ (α).

(29) Let X be a set of subgroups in group α.

X covers α iff ⊔ {↓ (x) ∈ X} =↓ (α) [6, p. 211]

(30) $\lambda x_n ... \lambda x ... \lambda x_1 .\{e \in$ *V:...*R(e)=x...$\} \rightarrow$
$\lambda x_n ... \lambda x ... \lambda x_1 .\{e \in$ *V:...^{C}R(e)=x...$\}$ [6, p. 211]

For Landman [20], cover readings are those in which there are plural agents of sums of events. Such readings are made possible by cover roles, which are defined in (28). If the plural role R has atoms d, and those atoms can be type-shifted down with the operation ↓, and we can take the sum of those type-shifted individuals, and that sum of type-shifted individuals is equal to the plural individual made from the group a, then a is a cover role. More plainly, if the agent of an event is a sum of groups, then that agent is a cover role. This is exactly what occurs when a sentence like (31-a) is used to describe the event that is described in (31-b)—i.e. an event in which $a \sqcup c$ and $b \sqcup c$ are the agents of separate song writing events.

(31) a. The musicians wrote songs.
b. Alex and Charlie wrote songs together, and Billie and Charlie wrote songs together.

In order to derive the interpretation in (27) from that of (31-b), the following must occur: ↑ ($a \sqcup c$) and ↑ ($b \sqcup c$) must be group atoms (made via the type shifting operation ↑[6]) that are the agents of events e and f respectively (32).

(32) ↑ ($a \sqcup c$) = Ag(e)
↑ ($b \sqcup c$) = Ag(f).

The plural agent of the sum of events e and f is equivalent to the sum of the groups ↑ ($a \sqcup c$) and ↑ ($b \sqcup c$):

(33) *Ag(e⊔f) = ↑ ($a \sqcup c$)⊔ ↑ ($b \sqcup c$) [20, p. 212]

The set of atoms below the plural agent in (33) is the set containing the two groups ↑ ($a \sqcup c$) and ↑ ($b \sqcup c$):

[6] one function of the type shifting operation ↑ is to turn plural individuals into group atoms; see [20] for details

(34) $\mathrm{AT}(^*\mathrm{Ag}(\mathrm{e}\sqcup\mathrm{f})) = \{\uparrow(a \sqcup c), \uparrow(b \sqcup c)\}$ [20, p. 212]

Given the definition of cover roles, (28), it is possible to take the closure under sum of the set of atoms below the plural agent, and therefore get the supremum of the groups of agents ((35)), which upshifted, is equivalent to the plural agent of events e and f ((36)).

(35) $\sqcup\{\downarrow(\mathrm{d}) \colon \mathrm{d} \in \mathrm{AT}(^*\mathrm{Ag}(\mathrm{e} \sqcup \mathrm{f}))\} = \sqcup\{a \sqcup c, b \sqcup c\} = a \sqcup b \sqcup c$

(36) $^*\mathrm{Ag}(\mathrm{e} \sqcup \mathrm{f}) = \uparrow(a \sqcup b \sqcup c)$

The type-shifting principle for verbs, (30), allows the meaning of the verb *write* to be shifted cover interpretations:

(37) $write \rightarrow \lambda y \lambda x.\{\mathrm{e} \in {}^*\mathrm{WRITE} : {}^{C}\mathrm{Ag}(\mathrm{e}) = \mathrm{x} \wedge {}^{C}\ \mathrm{Th}(\mathrm{e}) = \mathrm{y}\}$

This derivation provides a cover agent for the interpretation of (27) from the interpretation of (31-b).

While Landman [20] provides this mechanism for building plural predicates from covers, he argues that these are special cases that are not part of the interpretation of the verb. He argues that the sentences in question have four scopeless readings (double collective, collective-distributive, distributive-collective, and double-distributive–i.e. cumulative) if plural noun phrases fill the roles of the verb, and five other readings are available depending on how a particular scope mechanism is invoked. The cumulative interpretation is relational–i.e. it is not a statement about each individual denoted by the arguments of a transitive verb, and it is not about a predicate and one argument: it is about the relation between the predicate and its arguments. The cumulative reading (31-a) indicates that (i) there is a set of musicians, (ii) there is a set of songs, (iii) every one of the musicians wrote at least one of the songs, and (iv) every song was written by one or more of the musicians. The cumulative interpretation can be type-shifted to the "double cover interpretation", from which minimal cover interpretations can be derived, meaning that a relation between subgroups is expressed rather than a relation between individuals.

Adopting on the idea of Schwarzschild [24] that a plural predicate has one meaning that can index cover interpretations, and also the idea from Landman [20] that cover readings are derived from a double cover interpretation, we motivate an analysis in which plural predicates have a single, general interpretation from which all cover interpretations are indexed. The double cover reading from Landman [20] provides a weak, general meaning for the plural predicate, and by adding indexing, specific interpretations can be salient. The required translation entails the following rule.

(38) If α is a singular transitive verb phrase with translation A, then for any index i, $\exists e \in {}^*\mathrm{A} : {}^{C_i}\mathrm{Ag}(\mathrm{e}) = x \wedge {}^{C_i}\mathrm{Th}(\mathrm{e}) = (y)$ is the translation for the corresponding plural transitive verb phrase.

If a particular cover is not indexed in the context–i.e. the index is left unspecified as i–then the plural predicate is straightforwardly interpreted as a dual cover reading. The reading indicates (i) that there is a sum of writing events, (ii) there is a sum of groups of musicians (Alex, Billie, and Charlie in (20), (22), and (24)) as a plural agent, (iii) there is a sum of groups of songs as a plural theme:

$$(33) \quad [\![\textit{The musicians wrote songs}]\!] = \begin{cases} \exists e \in {}^*\text{WRITE}: \\ a \sqcup b \sqcup c = \sigma({}^*\text{MUSICIAN}) \wedge \\ {}^{C_i}\text{Ag(e)} = \uparrow (a \sqcup b \sqcup c) \wedge \\ \exists y \in {}^*\text{SONG} \wedge {}^{C_i}\text{Th(e)} = \uparrow (y) \end{cases}$$

While this seems very similar to a distributive interpretation (and in Landman's [20] framework, the double cover interpretation is a type-shifted double-distributive (cumulative) interpretation), without indexing a particular cover, it is impossible to tell exactly which (covers of) musicians wrote exactly which (covers of) songs. It is therefore distinct from Landman's [20] scoped distributive readings where the set of musicians would necessarily distribute to either distinct sets of songs, or the same set of songs.

4.1 Interpretation in Context: Quantification and Common Ground

While we have provided a semantic analysis of the interpretation of sentences like *The men wrote musicals*, it is still unclear what it means for a reading to be indexable in context given Gillon [11, 10], Schwarzschild [24], and Sternfeld [26] all provide different notions of what it means for such readings to be contextually available. Bianchi's [3] availability constraint provides a possible replacement for the notion of being contextually available and to the IPC vs. OPC debate in suggesting that communicative intentions have to be made available and readable in the objective context in order to help determine the content of the proposition. This solution, however, does not provide any indication of the relationship between the reading of a sentence in an ambiguous context and the reading(s) that may or may not be indexed in a given context.

To capture these relationships, we invoke a bipartie notion of Common Ground [25], as first called for by Krifka [18]. Berio et al. [2], modify Stalnaker's [25] classic notion of Common Ground by distinguishing between ICG (Immediate Common Ground) and GCG (General Common Ground). ICG and GCG are different levels of shared information that are both involved in conversation, though they are different in terms of their relation with the communication at hand. GCG contains semantic and world knowledge, and social and linguistic practices, which are stored in long term memory but not constantly recalled/activated in conversation. In ICG, discourse-specific referents are brought into focus by linguistic and perceptual mechanisms.

GCG includes knowledge about language in general, idiolects that are used in different linguistic groups, conventional implicatures, and conventions in general. Information such as encyclopedic entries, for instance, or definitions, are included in the GCG, and so are the principles and knowledge of logic that are

shared among individuals in a given community. However, not only propositional and linguistic information is involved in the GCG; on the contrary, perceptual information in form of memory traces and recollection can be found at the same level of CG, since they pertain to information that is stored in the long term memory—e.g. we can refer in conversation to a dog we saw earlier in the day. While the way we refer to the dog and the fact that we will bring it into the conversational focus in a matter of ICG, the fact that we have seen it is likely to be stored in episodic memory format. Note that his account of Common Ground is to be considered along the lines of the proposals made by Clark and Horton, [6, 14, 4], to describe shared information among conversation participants in terms of grounded cognitive mechanisms and to get away from the presuppositional account of Common Ground of the Stalnakarian tradition [25].

ICG is specific to communicative situation at hand, and includes linguistic and non-linguistic information. This is the level where triple co-presence as defined by [4, 6] is mostly relevant, i.e. the shared and joint attention of, for instance, two actors on an object. Tomasello [28] invokes a similar notion for language acquisition called "shared attentional frame". Co-presence does not have to be physical, but can be linguistic as well; in that case, joint attention can be focused through linguistic reference. Fundamentally, not everything that belongs to the shared immediate context is part of the speakers' ICG, since many things can be part of the environment, linguistic or non-linguistic, without being salient or attended to by the speakers. ICG, in this sense, is the level where elements like perceptual salience play a relevant role [5]. The ICG can be very rich at times, and very poor in other situations. This account predicts that, when the amount of information shared in the specific situation is minimal, the speakers will rely on information they share on a general level, opting possibly for what is the most frequent interpretation or, eventually, engaging in some strategic thinking to assess what is indeed shared in the situation (as in analysis of Common Ground and memory processes like [14, 15]).

The difference between ICG and GCG can be conceptualized in terms of which kind of memory is involved; while information and knowledge regarding word use and meaning and information about the world is a matter of General Common Ground and it involves long term memory and working memory, what is shared in the Immediate Common Ground is mostly a matter of working memory, as it entails the ability to keep track of contextual clues, of both linguistic and non-linguistic nature. In the same way working memory and long-term memory constantly interact, the interaction between ICG and GCG is constant and dynamic. This is based on what is commonly called *memory resonance*, i.e. the parallel elaboration of cues in working memory with stored, long-term memory information [8]. Horton and Gerrig [14], [15] make such an appeal to memory resonance to explain interaction at Common Ground, however, there is a focus on specific cases of shared information, i.e. cases of past physical co-presence.

As an illustration of the interaction between ICG and GCG, consider the following example. When speaking to another adult who is fluent in English, I can assume shared knowledge (GCG) of, say, the kind of entity and animal that

an elephant is. If the interlocutor knows me and my office well enough, the fact that I have elephant figurines on my desk is also in our GCG. If I am in my office, speaking over the phone to this interlocutor, then I will have to rely on linguistic cues to invoke the view of my desk they would have if they were there in person, or on my linguistic action of referring to elephants (ICG) to retrieve the information about figurines on my desk from the GCG, so my interlocutor will know I am not referring to an actual animal if I utter something like *An elephant fell*. In such a situation it will have become a matter of ICG that the the elephant is a figurine, that it is perceived by both of us, and so on. Note that, if the person is in the office with me, the simple presence of the elephants on my desk will not be sufficient for them to be part of the Immediate Common Ground with my interlocutor. What it will be necessary is for the elephants to be salient enough in the communicative situation, for example by me referring to them with linguistic or non-linguistic means.

Building on Berio et al. [2], we rely on a domain of quantification determined by the state of the world and the linguistic context shared by the speakers:

1. Readings in the domain of quantification are indexed by virtue of being present in the ICG via linguistic and non-linguistic clues that constitute shared information.
2. Additional readings are not normally indexed but are nevertheless decodable and inscribable according to the principles of semantics and logic that speakers share in the GCG. These readings, while derivable thanks to information that is part of the CG between participants, are not indexable in every communicative situation because they are not made relevant in the ICG.

The Immediate Common Ground is specific to a particular communicative situation; in this sense, the kind of information that is part of the ICG depends, case by case, on the linguistic and non-linguistic development of the conversation. The General Common Ground level is where we store information and knowledge that pertain to our use of language, in both explicit format, e.g. propositional knowledge, and implicit format, e.g. the heuristics and rules of logic we employ while speaking and communicating, along with conventions that we automatically follow in conversation, and information about the most common and frequent linguistic and non-linguistic conventions. The fact that implicit knowledge is part of the GCG is fundamental for our account of how Common Ground sheds light on the readings of plural covers. In the GCG we find the dual cover interpretation and the rules that can be used to derive other readings. This, obviously, does not imply that the formalization above is somehow part of the Common Ground among speakers; what is entailed in our competence with English, which is part of our knowledge in a broad sense, however, is the fact that we can make sense of a sentence like *The musicians wrote songs* with a double cover interpretation, according to which a writing event occurs, involving groups of musicians, and groups of songs as a result. It is at the level of ICG, on the other hand, that the specific readings are indexed. In other words, it is in specific communicative situation that specific cover readings can be understood.

With this distinction, we can succinctly describe the interpretation of sentences like (1) in different communicative situations, which also fits the empirical data.

(1) The men wrote musicals.

In the first situation, Wyatt and Grace know about the careers of Rodgers, Hammerstein, and Hart, because they attend a class on History of Broadway together. While walking across campus, Wyatt brings up his favorite Broadway writers, Rodgers, Hammerstein, and Hart, and stars, Joan Roberts, Gertrude Lawrence, and Mitzi Green. In this situation, (1) is easily compatible with (39).

(39) Hammerstein and Hart didn't write musicals individually or together.

The fact that Rodgers wrote musicals with Hammerstein and Hart respectively it is part of the GCG between Grace and Wyatt, and because of the conversation this reading and the fact that they are the referents of *the men* is part of the ICG. The intersection of the available cover of (1) and the interpretation of (39) includes a true reading so the two sentences are compatible.

In the second situation, Wyatt is talking to Kara, who does not attend the class and is not well-versed in Broadway history, so she does not know who the three men and women are. When Wyatt brings up their names, and then utters (1), she will only get the cumulative reading by virtue of this reading being the interpretation of such a sentence in an ambiguous context as is specified in the GCG. If Wyatt uttered (39), the pair of sentences would not make sense: the intersection of the available cover readings of these sentences would be the empty set. To make sense of (1) and (39),Kara would need the correct cover reading to be made available, for example with the statement in (40).

(40) Rodgers wrote musicals with Hammerstein, and he wrote musicals with Hart, but none of them wrote individually, and they never wrote all together.

With the distinction between ICG and GCG, we can also characterize the analyses of [11, 10], [24], [26] within a single framework. Gillon's [11, 10] assumption that both the beliefs and expectations of interlocutors and shape what readings are available corresponds to information in the GCG, while his assumption that context also shapes what readings are available corresponds to information in the ICG. Schwarzschild's [24] assumption that certain readings must be explicitly mentioned or otherwise salient because of non-linguistic discourse in order to be available also corresponds to our characterization of how the ICG shapes the domain of quantification. Finally, Sternfeld's [26] assumption that interlocutors choose particular readings in effort to make sentences true corresponds to the interaction of ICG and GCG, where interlocutors can invoke rules in the GCG to derive cover readings in the ICG. Lasersohn's [23] claim that certain readings are never available corresponds to readings that can be derived via rules in the GCG but are never brought into the ICG.

5 Conclusion

The proposed analysis provides a plausible explanation for why each condition was judged to be necessarily false in the empirical study. The ambiguous context in which the set-up sentences were presented was an empty ICG: There was no (non-)linguistic information that made any cover readings available, so the interpretation of the sentences evoked general linguistic principles in the GCG, which resulted in the default, double cover readings of the sentences in question. The follow-up sentences provided negative information about cover readings, however, because only the cumulative reading was available at this time, the intersection of the indexed cover readings in set-up sentences and the follow-up sentence was the empty set, and the follow-up sentences were judged to be false. What remains to be shown is whether or not certain intermediate readings are never judged to be true as Lasersohn [23] claims.

The fact that follow-up sentences with both *individually* and *together* were judged false significantly more frequently than those with only *individually* or *together*, is a phenomenon that must be accounted for. It might suggest that collective and distributive readings are more simple to derive than intermediate cover readings, which corresponds to the claim supported by many that these readings are more straightforwardly available—e.g. [10], [20], [21], [24]. However, it seems that these readings might not be able to be assumed to be part of the interpretation in ambiguous contexts in light of the evidence found in this study, and therefore the following question remains open: Why are collective and distributive readings more simple to get than intermediate cover readings?

One possible explanation for the difference in judgments is the respective frequencies of overtly collective, distributive, and intermediate cover readings. Both the number of lexical modifiers that specify collective or distributive readings and their frequency of use lend to the intuition that these two minimal cover readings are more salient than intermediate covers. After all, it seems there are no lexical modifiers that index specific intermediate covers, and situations in which intermediate covers are salient are likely to be less frequent than situations in which collective or distributive interpretations are salient. A corpus study looking for the relative frequencies of these readings could validate this hypothesis.

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