List readings of questions with conjoined singular *which*-phrases*

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1. Data of interest

Conjoined singular *which*-phrases typically invite *single-tuple answers* as in (1):

(1) Which boy and which girl sneezed?

a. #John and Mary sneezed, Fred and Sue sneezed, and Ed and Laura sneezed.
b. John and Mary sneezed.

We observe that in conjunction with certain predicates, such as *live together*, such questions can also give rise to a *list answer*, as in (2a), although there appears to be inter-speaker variation with respect to the availability of this answer (marked here with %).

(2) Which boy and which girl live together?

a. %John and Mary live together, Fred and Sue live together, and Ed and Laura live together.
b. John and Mary live together.

The following generalization seems to hold (see Appendix for experimental evidence): conjoined singular *which*-phrases have list readings (for some speakers) if the predicate is collective (e.g. *live together*, *like each other*, *are married*) but not if it is distributive (e.g. *are European*, *like math*).

The goal of this paper is to develop an account which will explain (i) why distributive and collective predicates differ in this particular way, and (ii) why speakers differ with respect to the availability of the list answer. In order to explain (i), we will adopt Winter's (2001) theory of plurality. A feature of this theory that is crucial for our purposes is that according to it, distributive and collective predicates have distinct semantic types. We

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will show that together with independently motivated morpho-syntactic restrictions on the covert distributivity operator (Winter 2001, de Vries 2015), the above contrast between (1) and (2) will be explained. In order to explain (ii), we claim that the list reading (2a) necessitates a more complex LF than the single tuple reading (2b), and this structural asymmetry manifests itself as preference for the latter reading, to a point that for some speakers the list answer is perceived as unavailable.

This paper is structured as follows. In Section 2, we will review Winter's (2001) theory plurality and in Section 3 the basics of question semantics. Then, we will explain in Section 4 how to derive the observed readings of (1) and (2), as well as why the list answer is unavailable for (1).

2. Plurality

2.1 Singular and Plural Nouns

We follow Winter (2001) in assuming that the domain of entities D_e consists of atomic entities only, and plural entities are sets of atomic entities. Singular NPs are assumed to be predicates of entities, i.e., type et, and plural NPs are predicates of sets of entities, i.e. type $\langle et, t\rangle$. For example, 'girl' and 'girls' denote the following functions.

(3) a. $[\![\text{girl}]\!]^w = \lambda x_e.\ x \in \mathsf{GIRL}_w$
b. $[\![\text{girls}]\!]^w = \lambda X_{et}.\ \forall x \in X[x \in \mathsf{GIRL}_w]$

We will not distinguish sets and their characteristic functions. Thus, we often regard (3a) as the set of girls in w, and (3b) as the set of sets of girls in w. From this semantics, we can isolate the semantic contribution of the plural morphology as follows (cf. Link 1983).

(4) $[\![\text{-s}]\!]^w = \lambda P_{et}.\lambda X_{et}.\forall x \in X[x \in P] \wedge \exists x'[x' \in X]$

In set theoretic terms, (4) applies to a set of entities and returns the power set of that set, minus $\emptyset$, i.e. $\wp(X)\backslash\emptyset = \wp^+(X)$.

2.2 Distributive Predicates

Let us now move on to verbs. Firstly, consider the following example containing a distributive predicate *sneezed* and a singular subject.

(5) Some girl sneezed.

We assume that distributive predicates like *sneezed* are predicates of entities, i.e. type et, and *some* denotes a cross-categorial existential quantifier of type $\langle \tau t, t\rangle$.

(6) a. $[\![\text{sneeze}]\!]^w = \lambda x_e.\ x \in \mathsf{SNEEZE}_w$
b. $[\![\text{some}]\!]^w = \lambda P_{\tau t}.\lambda Q_{\tau t}.\exists x_\tau[x \in P \wedge x \in Q]$

Then, the denotation of (5) is computed straightforwardly, as in (7).

(7) $[\![\text{[some girl] sneezed}]\!]^{w} = \exists x[x \in \mathsf{GIRL}_w \wedge x \in \mathsf{SNEEZE}_w]$

When the noun is plural as in (8), on the other hand, the computation is not as straightforward.

(8) Some girls sneezed.

In order to fix this, we follow the rich literature on distributivity (Link 1983, Roberts 1987, Lasersohn 1998, Winter 2001, Champollion 2016) and postulate a covert pluralization/distributivity operator $\mathcal{D}$. It creates a predicate of type $\langle \sigma t, t\rangle$ from a predicate of type σt by applying the latter to each member of the argument.

(9) $[\![\mathcal{D}]\!]^{w} = \lambda P_{\tau t}.\lambda X_{\tau t}.\forall x \in X[x \in P] \wedge \exists x'[x' \in X]$

Notice that this is a cross-categorial version of the plural morpheme *-s* in (4), meaning the plural morphology can be seen as a type of distributivity operator. Using $\mathcal{D}$, (8) can be analyzed as in (10).

(10) $$\left[\!\!\left[\; [\, [_{\langle\langle et,t\rangle,t\rangle}\ \text{some}\ [_{\langle et,t\rangle}\ \text{girl}\ \text{-s}\,]\,]\ [_{\langle et,t\rangle}\ \mathcal{D}\ \text{sneezed}\,]\,] \;\right]\!\!\right]^{w} = \exists X_{et}[X \in \wp^{+}(\mathsf{GIRL}_w) \wedge X \in \wp^{+}(\mathsf{SNEEZE}_w)]$$

2.3 Collective predicates

Collective predicates like *live together* are assumed to be predicates of plurals, i.e. of type $\langle et, t\rangle$ (we will not analyze the internal structure of *live together* here).

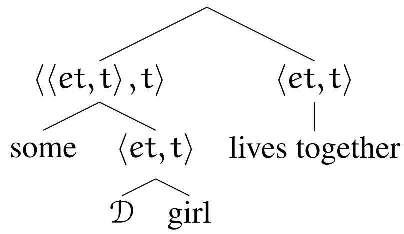
(11) $[\![\text{live together}]\!]^{w} = \lambda X_{et}.\ X \in \mathsf{LT}_w$

That collective predicates are incompatible with singular subjects is captured straightforwardly in this system as a type-mismatch. Concretely, the unacceptability of (12) is due to the fact that both the DP and the VP denote type $\langle et, t\rangle$ predicates, which cannot combine via functional application.

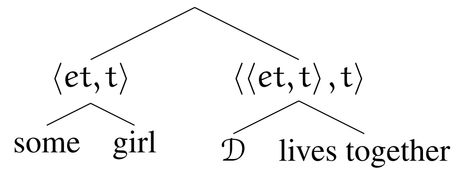
(12) *Some girl lives together.

Notice, however, that if the covert distributivity operator $\mathcal{D}$ were available here, the type-mismatch could be resolved. There are two possibilities, as illustrated in (13).

(13) a.



b.



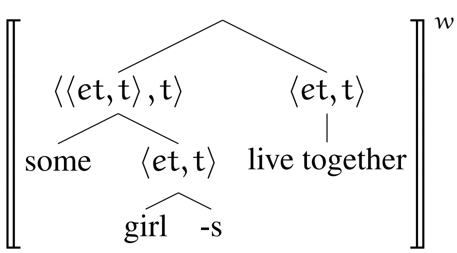
Since (12) is unacceptable, these structures need to be somehow blocked. To this end, we adopt Winter's (2001) and de Vries's (2015) idea that each occurrence of $\mathcal{D}$ needs to be morphosyntactically licensed by a [plural]-feature. In (12), the noun *girl* is singular and there is no DP-internal occurrence of [pl]. Therefore (13a) is not a possible parse of the sentence. Similarly, since the verb is marked as [singular], (13b) is also blocked. As we will see, this restriction on the distribution of $\mathcal{D}$ plays a crucial role in our analysis of conjoined singular *which*-phrases.

Now consider the plural version of (12), which is acceptable.

(14) Some girls live together.

Here, the quantifier phrase can combine directly with the collective predicate, and there is no need for $\mathcal{D}$.

(15)



$$= \exists \mathsf{X}_{et}[\mathsf{X} \in \wp^{+}(\mathsf{GIRL}_{w}) \wedge \mathsf{X} \in \mathsf{LT}_{w}]$$

This example also illustrates that while the occurrence of $\mathcal{D}$ necessitates a [plural]-feature, the presence of [plural]-feature does not imply the presence of $\mathcal{D}$.

2.4 Conjunction

As our main interests are conjoined singular *which*-phrases as in (1) and (2), we will now turn to the semantics of conjoined singular DPs (see Champollion 2015 for an analysis of conjoined plural NPs in this framework). As shown in (16), conjoined singular DPs are compatible with both distributive and collective predicates.

$$\text{(16)}\quad \left.\begin{array}{l}\text{John and Mary}\\ \text{A boy and a girl}\end{array}\right\}\left\{\begin{array}{ll}\text{live together.} & \text{(Distributive)}\\ \text{sneezed.} & \text{(Collective)}\end{array}\right.$$

Winter (2001) derives both readings with a single intersective meaning for *and* given in (17) (see also Champollion 2015).

(17) $[\![\text{and}]\!]^w = \lambda P_{\tau t}.\lambda Q_{\tau t}.\lambda x_\tau.\ x \in P \wedge x \in Q$

Let's start with the simpler case involving conjoined proper names. We take proper names to denote Montagovian individuals of type $\langle et, t\rangle$, as in (18a) and (18b). Combining them via (17) yields the generalized quantifier in (18c). Set-theoretically, this is the set of properties true of both John and Mary.

(18) a. $[\![\text{John}]\!]^w = \lambda P_{et}.\ j \in P$ b. $[\![\text{Mary}]\!]^w = \lambda P_{et}.\ m \in P$
c. $[\![\text{John and Mary}]\!]^w = \lambda P_{et}.\ j \in P \wedge m \in P$

The distributive reading of *John and Mary sneezed* is straightforwardly derived.

(19) $[\![\text{John and Mary sneezed}]\!]^w = j \in \mathsf{SNEEZE}_w \wedge m \in \mathsf{SNEEZE}_w$

Next, we turn to collective interpretations of conjoined proper names. Recall that collective predicates are only true of pluralities, and they are of type $\langle et, t\rangle$. Therefore, they cannot directly combine with (18). In order to derive the collective interpretation of conjoined nouns, two type-shifting operations must be employed, the first of which is the minimization operator $\mathcal{M}$ in (20). $\mathcal{M}$ applies to a quantifier Q of type $\langle et, t\rangle$, which is a set of sets of entities, and gives back the set of minimal sets in Q.

(20) $[\![\mathcal{M}]\!]^w = \lambda Q_{\langle et,t\rangle}.\lambda P_{et}.P \in Q \wedge \forall P'[P' \subset P \rightarrow P' \notin Q]$

In the case of *John and Mary*, there is a unique minimal set, which is the set consisting of John and Mary and nothing else.

(21) $[\![\mathcal{M}]\!]^w([\![\text{John and Mary}]\!]^w) = [\![\mathcal{M}]\!]^w(\{P_{et} \mid j \in P \wedge m \in P\})$
$= [\![\mathcal{M}]\!]^w(\{\{j,m\},\{j,m,a\},\{j,m,b\},\{j,m,a,b\}\ldots\}) = \{\{j,m\}\}$

(21) still cannot combine with a collective predicate for type reasons. In order to fix this, Winter postulates the operation of *Existential Raising*, $\mathcal{E}$, which is essentially a covert version of *some* in (6b) (cf., Partee 1986).

(22) $[\![\mathcal{E}]\!]^w = \lambda P_{\tau t}.\lambda Q_{\tau t}.\ \exists x[x \in P \wedge x \in Q]$

When applied to a type-$\langle et, t\rangle$ quantifier, it yields something that can take a collective predicate. Specifically, the interpretation of *John and Mary live together* is as in (23).

(23) $[\![\mathcal{E}]\!]^w([\![\mathcal{M}]\!]^w([\![\text{John and Mary}]\!]^w))([\![\text{live together}]\!]^w)$
$= [\![\mathcal{E}]\!]^w(\{\{j,m\}\})(\{X_{et} \mid X \in \mathsf{LT}_w\})$
$= \exists X_{et}[X \in \{\{j,m\}\} \wedge X \in \mathsf{LT}_w]$
$= \{j,m\} \in \mathsf{LT}_w$

Conjoined singular quantifiers like *a boy and a girl* can be given an analogous analysis. Assuming that *a NP* is an existential quantifier over entities, the intersective semantics of *and* derives the following denotation for *a boy and a girl*.

(24) $[\![\text{a boy and a girl}]\!]^w$
$= [\![\text{and}]\!]^w(\lambda P.\ \exists x[x \in \mathsf{BOY}_w \wedge x \in P])(\lambda P.\ \exists y[y \in \mathsf{GIRL}_w \wedge y \in P])$
$= \{Q_{et} \mid \exists x \exists y[x \in \mathsf{BOY}_w \wedge y \in \mathsf{GIRL}_w \wedge x, y \in Q]\}$

This semantics for the conjoined nominal can combine directly with a distributive predicate, delivering the distributive interpretation in (25).

(25) $[\![\text{A boy and a girl sneezed}]\!]^w = \exists x \exists y[x \in \mathsf{BOY}_w \wedge y \in \mathsf{GIRL}_w \wedge x, y \in \mathsf{SNEEZE}_w]$

As in the case of conjoined proper names, in order to derive the collective interpretation we need to appeal to the $\mathcal{M}$ and $\mathcal{E}$ operators. Note that the result of applying $\mathcal{M}$ to (25) is a set of sets containing one boy and one girl and nothing else. Unlike for *John and Mary*, there are multiple such sets. $\mathcal{E}$, then, existentially quantifies over them.

(26) $[\![\mathcal{E}]\!]^w([\![\mathcal{M}]\!]^w([\![\text{a boy and a girl}]\!]^w))([\![\text{live together}]\!]^w)$
$= [\![\mathcal{E}]\!]^w(\{\{x, y\} \mid x \in \mathsf{BOY}_w \wedge y \in \mathsf{GIRL}_w\})(\{X_{et} \mid X \in \mathsf{LT}_w\})$
$= \exists X_{et}[X \in \{\{x, y\} \mid x \in \mathsf{BOY}_w \wedge y \in \mathsf{GIRL}_w\} \wedge X \in \mathsf{LT}_w]$

The distribution of $\mathcal{E}$ needs to be constrained. If it could be used without $\mathcal{M}$, the following sentences will have coherent interpretations.

(27) a. #A boy lives together.
b. [$\mathcal{E}$ a boy] lives together.

(28) a. #A boy and a girl are a trio.
b. [$\mathcal{E}$ a boy and a girl] are a trio.

Winter (2001) assumes that $\mathcal{E} \circ \mathcal{M}$ is a single type-lifting operation. Since our analysis of conjoined singular *which*-phrases to be presented in Section 4 requires an application of $\mathcal{D}$ between these two operators, we assume that $\mathcal{E}$ is only licensed in the presence of $\mathcal{M}$.

To summarize, both distributive and collective readings can be derived from the intersective semantics of *and*. The collective interpretation requires extracting a minimal set (= plural individual) $\{x, y\}$ in the extension of the quantifier, which combines with the collective predicate via existential raising.

3. Question semantics

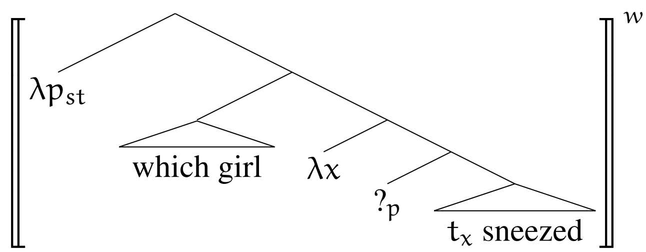
We adopt a theory of questions wherein a question denotes the set of its possible answers. Following Karttunen (1977) we take *wh*-phrases to denote existential quantifiers, (29).

(29) $[\![\text{which girl}]\!]^w = \lambda Q_{et}.\exists x[x \in \mathsf{GIRL}_w \wedge x \in Q]$ $(= [\![\text{a girl}]\!]^w)$

The interrogative C head hosts a question operator '?' which carries a [WH] feature that drives the *wh*-movement of the *wh*-phrase. Semantically, the question operator creates a 'proto-question'.

(30) $[\![?]\!]^w = \lambda q_{st}.p = q$

The free variable p here gets bound at the top-most node, delivering the set of possible answers, as in (31).[1]

(31) 

$= \lambda p.\exists x[x \in \mathsf{BOY}_w \wedge p = \lambda w'.\ x \in \mathsf{SNEEZE}_{w'}]$

In addition, we adopt Dayal's (1996) ANS-operator to account for the availability of single-tuple and list answers. The ANS-operator maps an answer set Q to the maximally informative and true proposition in Q, which is similar in a sense to the definite article. Crucial for us is the assumption that ANS presupposes that there is only one maximally informative true answer in the question denotation.

(32) $[\![\mathrm{ANS}]\!]^w = \lambda Q_{\langle st,t\rangle} : \exists! p[p \in \mathrm{maxinf}_w(Q)].\ \iota p[p \in \mathrm{maxinf}_w(Q)]$

For our examples, maximally informative true answers in Q are propositions in Q that are true and are not entailed by other true propositions in Q.

Consider a possible world w_1 where Joan sneezed, and Becky and Mary didn't sneeze, and they are the only relevant girls in the model. When applied to the set of propositions in (31), ANS returns the maximally informative true proposition: $\lambda w'.\ j \in \mathsf{SNEEZE}_{w'}$.

(33) $$[\![\mathrm{ANS}]\!]^{w_1}\left(\left\{\begin{array}{l}\lambda w'.\ j \in \mathsf{SNEEZE}_{w'},\\ \lambda w'.\ b \in \mathsf{SNEEZE}_{w'},\\ \lambda w'.\ m \in \mathsf{SNEEZE}_{w'}\end{array}\right\}\right) = \lambda w'.\ j \in \mathsf{SNEEZE}_{w'}$$

Consider next another possible world w_2 where Joan and Becky sneezed, but Mary didn't. Since $\lambda w'.\ j \in \mathsf{SNEEZE}_{w'}$ and $\lambda w'.\ b \in \mathsf{SNEEZE}_{w'}$ are both true and equally informative, the presupposition of the ANS operator is not satisfied and presupposition failure ensues. This means that singular *which*-phrases give rise to a uniqueness presupposition as a result of the interplay with the presupposition of ANS.

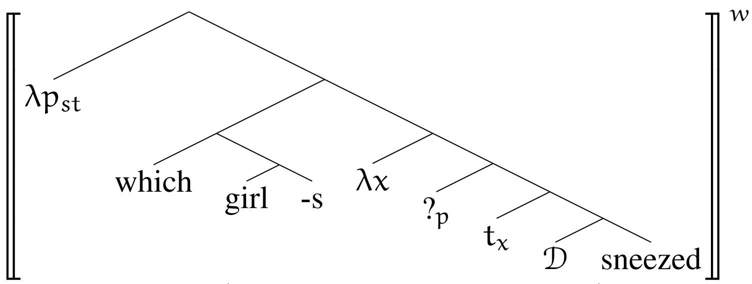
Next we turn to questions with plural *which*-phrases, such as (34).

[1] This only derives the *de re* reading of the *which*-phrase. One way to derive the *de dicto* reading would be to reconstruct the NP part of the *which*-phrase to the base position.

(34) Which girls sneezed?

As in the case of the declarative counterpart in (8), $\mathcal{D}$ is necessary for type reasons, as illustrated by (35). We assume that this occurrence of $\mathcal{D}$ is licensed by the [plural]-feature carried by the predicate, although it is not morphologically expressed in this case.

(35)



$$= \lambda p. \exists X_{et}[X \in \wp^{+}(\mathsf{GIRL}_w) \wedge p = \lambda w'.\ X \in \wp^{+}(\mathsf{SNEEZE}_{w'})]$$

$$= \left\{ \begin{array}{l} \lambda w'.\ \{j\} \in \wp^{+}(\mathsf{SNEEZE}_{w'}), \\ \lambda w'.\ \{b\} \in \wp^{+}(\mathsf{SNEEZE}_{w'}), \\ \lambda w'.\ \{m\} \in \wp^{+}(\mathsf{SNEEZE}_{w'}), \\ \lambda w'.\ \{j,b\} \in \wp^{+}(\mathsf{SNEEZE}_{w'}), \\ \lambda w'.\ \{j.m\} \in \wp^{+}(\mathsf{SNEEZE}_{w'}), \ldots \end{array} \right\} = \left\{ \begin{array}{l} \lambda w'.\ j \in \mathsf{SNEEZE}_{w'}, \\ \lambda w'.\ b \in \mathsf{SNEEZE}_{w'}, \\ \lambda w'.\ m \in \mathsf{SNEEZE}_{w'}, \\ \lambda w'.\ j,b \in \mathsf{SNEEZE}_{w'}, \\ \lambda w'.\ j,m \in \mathsf{SNEEZE}_{w'}, \ldots \end{array} \right\}$$

Unlike in the previous case with a singular *which*-phrases, ANS will be defined when multiple girls sneezed, because there is bound to be a unique true answer in this set that entails all the others. In w_2 above, for example, the proposition $\lambda w'.\ j, b \in \mathsf{SNEEZE}_{w'}$ is the maximally informative true answer. As a consequence, the answer will look like 'Joan and Becky sneezed' or 'Joan sneezed and Becky sneezed'. This is a list answer.[2]

We will discuss plural *which*-phrases with collective predicates in Section 4.5 after presenting our analysis of conjoined singular *which*-phrases.

4. The analysis

We are now in a position to account for questions involving conjoined singular *which*-phrases with distributive and collective predicates. The present section will proceed as follows. Section 4.1 deals with the single-tuple reading of questions with conjoined singular *which*-phrases. Section 4.2 turns to the derivation of the list reading for such questions with collective predicates, and finally Section 4.3 explains why distributive predicates do not allow for list readings with conjoined singular *which*-phrases. Section 4.4 addresses the saliency of list readings and lastly, Section 4.5 discusses list readings of questions with plural *which*-phrases with collective predicates.

[2] It should be remarked that what we call list answers are qualitatively distinct from so-called *pair-list answers* of questions like (i) (Chierchia 1993, Dayal 1996).

(i) a. Which boy likes which girl? b. Which girl does each boy like?

As Dayal (1996) argues, list and pair-list answers are likely to be due to different grammatical mechanisms.

4.1 Single-tuple readings

The single-tuple readings of conjoined singular *which*-phrases with distributive predicates like *sneezed* can be derived straightforwardly without covert operators. For example, (1), which is repeated here as (36a), denotes (36b).

(36) a. Which boy and which girl sneezed?
b. $\lambda p_{st}.\exists x,y[x \in \mathsf{BOY}_w \wedge y \in \mathsf{GIRL}_w \wedge p = [\lambda w'.\ x,y \in \mathsf{SNEEZE}_{w'}]]$

If $\mathsf{BOY}_w = \{b_1, b_2\}$ and $\mathsf{GIRL}_w = \{g_1, g_2\}$, (36b) will be the four-membered set in (37).

(37) $$\left\{ \begin{array}{ll} \lambda w'.\ b_1, g_1 \in \mathsf{SNEEZE}_{w'}, & \lambda w'.\ b_2, g_2 \in \mathsf{SNEEZE}_{w'}, \\ \lambda w'.\ b_1, g_2 \in \mathsf{SNEEZE}_{w'}, & \lambda w'.\ b_2, g_1 \in \mathsf{SNEEZE}_{w'} \end{array} \right\}$$

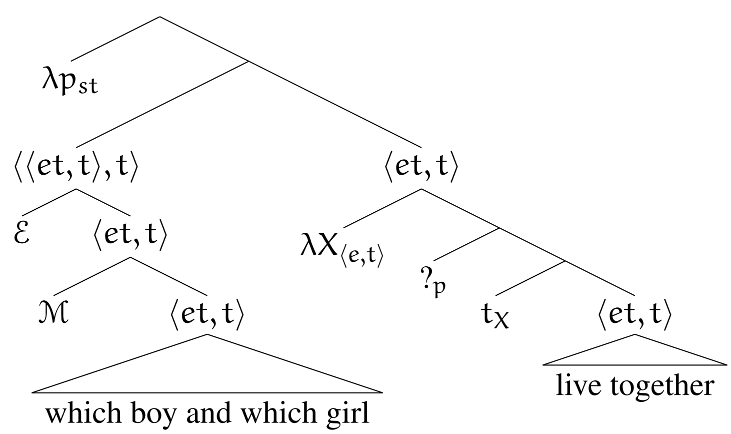
When applied to (37), ANS introduces the presupposition that only one of these propositions is true in the world of evaluation. In other words, the question presupposes that a single boy and a single girl sneezed. As a result, a single-tuple interpretation is forced.

Next we turn to (2), which contains a collective predicate.

(2) Which boy and which girl live together?

As in the case of its declarative counterpart *A boy and a girl live together*, (37) necessarily requires $\mathcal{E}$ and $\mathcal{M}$. Consider the following LF.

(38) a.



With $\mathsf{BOY}_w = \{b_1, b_2\}$ and $\mathsf{GIRL}_w = \{g_1, g_2\}$, (38) will denote (39).

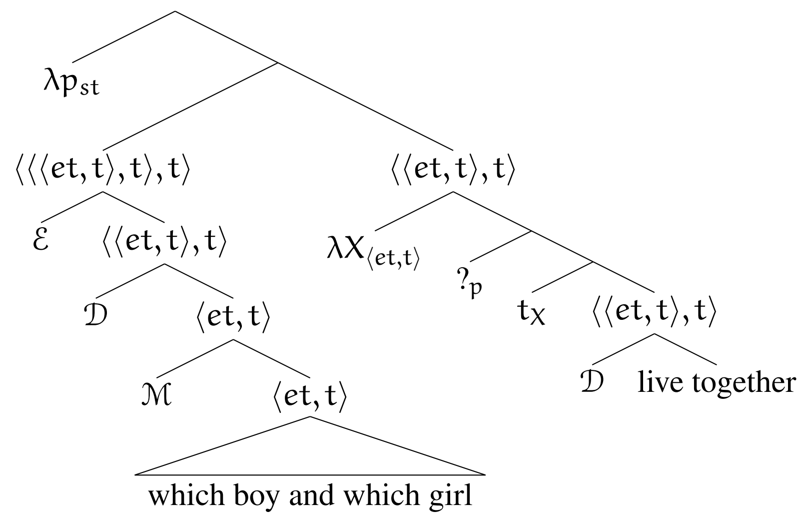
(39) $$\lambda p.\exists X_{et}[X \in \{\{x,y\} \mid x \in \mathsf{BOY}_w \wedge y \in \mathsf{GIRL}_w\} \wedge p = [\lambda w'.\ X \in \mathsf{LT}_{w'}]]$$
$$= \left\{ \begin{array}{ll} \lambda w'.\{b_1, g_1\} \in \mathsf{LT}_{w'}, & \lambda w'.\{b_2, g_2\} \in \mathsf{LT}_{w'}, \\ \lambda w'.\{b_1, g_2\} \in \mathsf{LT}_{w'}, & \lambda w'.\{b_2, g_1\} \in \mathsf{LT}_{w'} \end{array} \right\}$$

We see that the propositions in (39) are independent, meaning that the only situation in which such a question would be defined is one where there is a single boy-girl pair that lives together, hence the single-tuple answer.

4.2 List reading with a collective predicate

Recall that (2) also has a list reading, at least for some speakers. We claim that in order to derive such a reading, a different LF must be employed, namely one involving two instances of the $\mathcal{D}$ operator, one at the level of the *which*-phrase and another at the level of the collective predicate, as in (40) (cf. (38)).

(40)



We assume that both occurrences of $\mathcal{D}$ here are morphologically licensed. Specifically, the subject-internal one is licensed by the [plural]-feature introduced by *and* (Sauerland 2003, 2008), and the one on VP is licensed by the [plural]-feature carried by the verb, which is morphologically inert. Let's understand what this LF amounts to. Applying $\mathcal{M}$ to $[\![\text{which boy and which girl}]\!]^w$ delivers the set of all possible boy-girl pairs, and applying $\mathcal{D}$ to this set delivers its power set, i.e. the set of all possible sets of boy-girl pairs. This is illustrated by (41) with two boys and two girls.

(41)
$$
\begin{aligned}
&[\![\mathcal{D}]\!]^w([\![\mathcal{M}]\!]^w([\![\text{which boy and which girl}]\!]^w))\\
&= \wp^{+}(\{\{b_1,g_1\},\{b_2,g_1\},\{b_1,g_2\},\{b_2,g_2\}\})\\
&= \left\{ \begin{array}{c} \{\{b_1,g_1\},\{b_2,g_1\},\{b_1,g_2\},\{b_2,g_2\}\}, \\ \{\{b_1,g_1\},\{b_2,g_1\},\{b_1,g_2\}\}, \quad \{\{b_1,g_1\},\{b_2,g_1\},\{b_2,g_2\}\}, \quad \ldots \\ \{\{b_1,g_1\},\{b_1,g_2\}\}, \quad \{\{b_1,g_1\},\{b_2,g_1\}\}, \quad \ldots \\ \{\{b_1,g_1\}\}, \quad \{\{b_2,g_1\}\}, \quad \{\{b_1,g_2\}\}, \quad \{\{b_2,g_2\}\} \end{array} \right\}
\end{aligned}
$$

Applying $\mathcal{D}$ to the collective predicate *live together* delivers the power set of all possible sets of cohabitants. Lastly, in order for the complex predicate denoting the power set of boy-girl pairs to be able to quantify in, we need to existentially raise this predicate via $\mathcal{E}$, which will deliver the following question denotation, corresponding to the set in (43).

(42) $\lambda p.\exists X_{\langle et,t\rangle}[X \in \wp^{+}([\![\mathcal{M}]\!]^{w}([\![\text{a boy and a girl}]\!]^{w})) \wedge p = \lambda w'.\, X \in \wp^{+}(\mathsf{LT}_{w'})]$

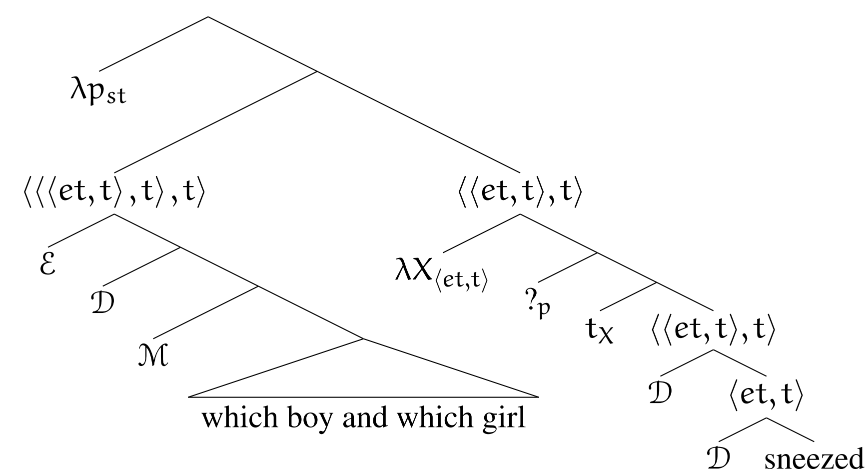
(43)
$$\left\{\begin{array}{l} \lambda w'.\,\{\{b_1,g_1\}\} \in \wp^{+}(\mathsf{LT}_{w'}),\\ \lambda w'.\,\{\{b_2,g_2\}\} \in \wp^{+}(\mathsf{LT}_{w'}),\\ \lambda w'.\,\{\{b_1,g_2\}\} \in \wp^{+}(\mathsf{LT}_{w'}),\\ \lambda w'.\,\{\{b_2,g_1\}\} \in \wp^{+}(\mathsf{LT}_{w'}),\\ \lambda w'.\,\{\{b_1,g_1\},\{b_2,g_2\}\} \in \wp^{+}(\mathsf{LT}_{w'}),\\ \lambda w'.\,\{\{b_1,g_2\},\{b_2,g_1\}\} \in \wp^{+}(\mathsf{LT}_{w'}) \end{array}\right\} = \left\{\begin{array}{l} \lambda w'.\,\{b_1,g_1\} \in \mathsf{LT}_{w'},\\ \lambda w'.\,\{b_2,g_2\} \in \mathsf{LT}_{w'},\\ \lambda w'.\,\{b_1,g_2\} \in \mathsf{LT}_{w'},\\ \lambda w'.\,\{b_2,g_1\} \in \mathsf{LT}_{w'},\\ \lambda w'.\,\{b_1,g_1\},\{b_2,g_2\} \in \mathsf{LT}_{w'},\\ \lambda w'.\,\{b_1,g_2\},\{b_2,g_1\} \in \mathsf{LT}_{w'} \end{array}\right\}$$

It is worth noting at this point that this analysis of list answers with conjoined singular *which*-phrases is no different from what we assumed in Section 3 for plural *which*-questions with distributive predicates, like *which boys sneezed?*. Just like in that case, the set in (43) is closed under conjunction, meaning that there will always be a maximally informative proposition. For example, when b_1 and g_1 live together and b_2 and g_2 live together (and no other boy-girl pairs live together), then ANS will return $\lambda w'.\,\{\{b_1,g_1\},\{b_2,g_2\}\} \in \wp^{+}(\mathsf{LT}_{w'})$. This amounts to a list answer.

4.3 List reading with a distributive predicate and restrictions on $\mathcal{D}$

We have just seen that conjoined singular *which*-phrases with collective predicates like *live together* have two possible LFs which differ in whether $\mathcal{D}$ is employed. It is, then, natural to ask if the same strategy could be employed to derive the unattested list answers for cases with distributive predicates. Due to the assumption that distributive predicates are of type et, rather than $\langle et,t\rangle$, there need to be two occurrences of $\mathcal{D}$ at the VP level, as in (44).

(44)



This LF, if available, would in fact yield the unattested list answer. However, it is syntactically made illicit on the assumption that *each occurrence of* $\mathcal{D}$ needs to be licensed by a [plural]-feature (Winter 2001, de Vries 2015). If so, [plural] on the verb can only introduce one $\mathcal{D}$, which would not resolve the type-mismatch here. Consequently, the only available LF for (1) is the one without any $\mathcal{D}$ operators.

4.4 Saliency of list reading with collective predicates

The list reading of (2) is judged less good than the single tuple reading and some speakers even perceive it as unavailable. We resort to the structural complexity to account for this. That is, under the present account, the single tuple reading requires only $\mathcal{E}$ and $\mathcal{M}$, while the list reading additionally requires two instances of $\mathcal{D}$, as in (45).

(45) a. [$\mathcal{E}$ $\mathcal{M}$ which boy and which girl] [live together]? *Single-tuple*
b. [$\mathcal{E}$ $\mathcal{D}$ $\mathcal{M}$ which boy and which girl] [$\mathcal{D}$ live together]? *List*

We assume that in such a situation, the simpler LF is preferred. Speakers might differ in how willing they are to complicate the LF, hence the inter-speaker variation.

4.5 List answers with plural *which*-phrases

Lastly, let us discuss plural *which*-phrases with collective predicates, e.g. (46). This is parallel to the declarative counterpart in (14), and an LF without $\mathcal{D}$ is available. Omitting the details, (46a) will denote (46b).

(46) a. Which girls live together?
b. $\lambda p.\exists X_{et}[X \in \wp^+(\mathsf{GIRL}_w) \wedge p = \lambda w'.\, X \in \mathsf{LT}_{w'}]$

Although there are certain entailments among the propositions in (46b) guaranteed by the lexical semantics of *live together*, ANS will not be defined for it in certain cases. For instance, if g_1 and g_2 live together and g_3 and g_4 live together, there will be two maximally informative propositions in (46b). This means that (46b) is a single-tuple reading.

We could employ the same strategy as in the case of conjoined singular *which*-phrases to generate the list reading for such a question. Specifically, with two occurrences of $\mathcal{D}$, (47a) will yield the reading in (47b). The set of propositions in (46b) constitutes a complete semi-lattice with respect to entailment, and so a list reading is predicted to be available.

(47) a. [which $\mathcal{D}$ girls] [$\mathcal{D}$ live together]?
b. $\lambda p.\exists X_{\langle et,t\rangle}[X \in \wp^+(\wp^+(\mathsf{GIRL}_w)) \wedge p = \lambda w'.\, X \in \wp^+(\mathsf{LT}_{w'})]$

One prediction of this analysis is that the list reading of (46a) should be as latent as the list reading of questions with conjoined singular *which*-phrases like (2). This does not seem to be the case, however. In order fix this, we postulate another way to derive the list reading of (46) via an intermediate distributivity operator $\mathcal{C}$ (cf. Gillon 1987, Schwarzschild 1996); Y is a cover of X (written $\mathrm{Cov}(Y,X)$) iff $Y \subseteq \wp^+(X)$ and $\bigcup Y = X$). Instead of quantifying over members of the subject X, $\mathcal{C}$ quantifies over subsets of X.

(48) $[\![\mathcal{C}]\!]^w = \lambda P_{\tau t}.\lambda X_{\tau t}.\exists Y_{\langle \tau t,t\rangle}[\mathrm{Cov}(Y,X) \wedge \forall Z \in Y[Y \in P]]$

Under the LF in (49a), the attested list reading can now be derived straightforwardly.

(49) a. [which girls] [$\mathcal{C}$ live together]?

b. $\lambda p.\exists X_{et}[X \in \wp^{+}(\mathsf{GIRL}_{w}) \wedge p = \lambda w'.\, X \in [\![\mathcal{C}]\!]^{w'}(\mathsf{LT}_{w'})]$

Consider the following situation: g_1 and g_2 live together, and so do g_3 and g_4. In this situation, X will denote the set consisting of these four girls, which itself is a subset of $\wp^{+}(\mathsf{GIRL}_{w})$. Next we need to check whether X is an element of $[\![\mathcal{C}]\!]^{w'}(\mathsf{LT}_{w'})$. This will be satisfied as long as we can find a cover of X such that every element of it is an element of $\mathsf{LT}_{w'}$. In this situation, the cover that satisfies this condition is $\{\{g_1, g_2\}, \{g_3, g_4\}\}$ since both elements are members of $\mathsf{LT}_{w'}$. We see then that by applying $\mathcal{C}$ to the predicate, we can derive the list reading of (46a). Note that $\mathcal{C}$ will not generate new readings for conjoined singular *which*-phrases.

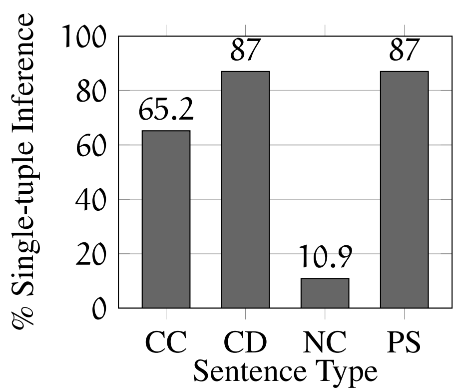
Appendix

In order to test the generalization regarding the difference between distributive and collective predicates as in (1) and (2), we conducted an experiment. The task of the experiment is an inferential task with presuppositions. Each target trial consisted of an interrogative sentences like (1) and (2) and a declarative sentence stating that only one pair satisfied the predicate. Subjects were asked to judge whether asking the interrogative sentence necessarily commits one to believe that the declarative sentence is true. In addition to conjoined singular *which*-phrases with distributive predicates (1) (CD) and collective predicates (2) (CC), we also included two baseline conditions, namely non-conjoined multiple *which*-questions (NC) like (50a), which are expected to readily allow for list answers, and questions that only admit a single tuple answer for pragmatic reasons (PS) like (50b), which should not allow list answers.

(50) a. Rhonda knows which kid received which present.

b. Pam knows which spy killed the president with which weapons.

(51) *Experimental results*



Each condition had six items, and they were presented with 16 filler items. The results from 23 self-reported native speakers of English recruited on Amazon Mechanical Turk are summarized in the graph in (51). The difference between CC vs. CD is statistically significant (Wilcoxson signed rank test: $W = 38, Z = -2.357, p = 0.03$). Similarly, CC vs. PS is also statistically significant ($W = 25.5, Z = -2.5, p = 0.02$), unlike CD vs. PS.

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