Pair-List Readings of Conjoined Singular *Which*-Phrases

We present experimental evidence that conjoined singular *which*-phrases give rise to pair-list readings with collective predicates but not with distributive predicates. The data suggest that the pair-list readings are relatively latent, and there is likely to be inter-speaker variation. We account for this novel observation by using Winter's (2001) theory of plurality, coupled with Dayal's (1996) answerhood operator.

Sentences like (1) with multiple singular *which*-phrases often give rise to a pair-list (PL) and single-pair (SP) reading. A complete answer to the PL reading of (1) determines for each boy which girl he likes. A complete answer to the SP reading is about a single boy-girl pair.

We report experimental evidence suggesting that conjoined singular *which*-phrases allow for the PL reading, but that the availability of this reading is dependent on the nature of the predicate. For example, (2a) has a PL reading, while (2b) doesn't.

(1) Which boy likes which girl?

(2) a. Which boy and which girl live together?
b. Which boy and which girl smoke?

The following generalization seems to hold: conjoined singular *which*-phrases have PL readings 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*).

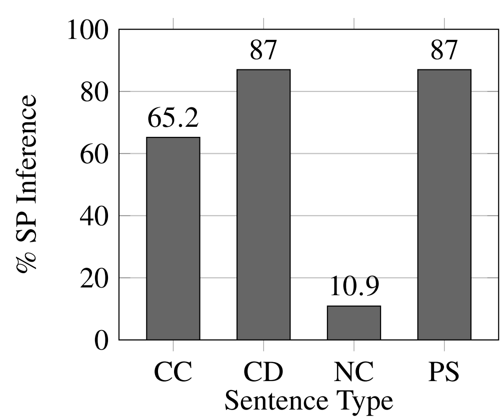
However, the PL reading of (2a) appears to be marked and less prominent than the SP reading, and some speakers we consulted informally report that the PL reading is unavailable, suggesting possible inter-speaker variation. For this reason, we collected quantitative data in a controlled experiment in order to make the observation more concrete.

The experiment employed an inferential task where participants were shown two sentences, S1 and S2. The task was to judge whether sincerely uttering S1 necessarily commits one to assume S2 to be true. The experiment had 4 conditions, depending on the type of S1:

- Conjoined-Collective (CC): *Ann knows which girl and which boy hugged each other.*
- Conjoined-Distributive (CD): *Tami knows which lawyer and which judge studied.*
- Non-Conjoined (NC): *Rhonda knows which kid received which present.*
- Pragmatically forced SP (PS): *Pam knows which spy killed the president with which weapon.*

S2 was essentially uniform across items, e.g. for the first example above, *Only one girl and one boy hugged each other*. Each target condition had 6 items. In addition, there were 16 filler items. Each subject saw two items from each of the 4 target conditions, and was assigned to one of three possible groups. The results summarised in the figure are based on the 23 self-claimed native speakers of English employed on Amazon Mechanical Turk. 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 (Wilcoxson signed rank test: $W = 25.5, Z = -2.5, p = 0.02$). On the other hand, CD and PS are not different.

These results indicate that conjoined singular *which*-phrases do give rise to PL readings with collective predicates, but not with distributive predicates. It should also be noted that the PL readings of conjoined singular *which*-phrases are not as easily available as PL readings of non-conjoined singular *which*-phrases (CC vs. NC). These observations confirm our generalisation above.



In addition, some of the participants did not report the PL reading at all, which is indicative of inter-speaker variation. The results also indicate possible inter-item variation such that PL reading is more robust with certain collective predicates than others. However, given the small size of the present experiment (2 CC items per subject, 6–10 subjects per CC item), we will leave further investigation on possible variation for another occasion.

We claim that the SP denotation of (2a) is a set of propositions that looks like (3), with $\mathsf{BOY}_w = \{ b_1, b_2 \}$ and $\mathsf{GIRL}_w = \{ g_1, g_2 \}$.

(3) $\left\{\begin{array}{l}\lambda w'.\ \{b_1,g_1\}\in \mathsf{LT}_{w'},\\ \lambda w'.\ \{b_2,g_2\}\in \mathsf{LT}_{w'},\\ \lambda w'.\ \{b_1,g_2\}\in \mathsf{LT}_{w'},\\ \lambda w'.\ \{b_2,g_1\}\in \mathsf{LT}_{w'}\end{array}\right\}$ (4) $\left\{\begin{array}{ll}\lambda w'.\ \{b_1,g_1\}\in \mathsf{LT}_{w'}, & \lambda w'.\ \{b_1,g_1\},\{b_2,g_2\}\in \mathsf{LT}_{w'},\\ \lambda w'.\ \{b_2,g_2\}\in \mathsf{LT}_{w'}, & \lambda w'.\ \{b_1,g_2\},\{b_2,g_1\}\in \mathsf{LT}_{w'},\\ \lambda w'.\ \{b_1,g_2\}\in \mathsf{LT}_{w'}, & \lambda w'.\ \{b_1,g_1\},\{b_2,g_2\},\\ \lambda w'.\ \{b_2,g_1\}\in \mathsf{LT}_{w'}, & \qquad\{b_1,g_2\},\{b_2,g_1\}\in \mathsf{LT}_{w'}\\ \lambda w'.\ \{b_1,g_1\},\{b_2,g_2\}, & \end{array}\right\}$

We adopt Dayal's (1996) suggestion that an answer to a question should denote the maximally informative proposition in the answer set. The answer operator presupposes that there is only one true maximally informative answer in the question denotation, and picks it out. Since the propositions in (3) are independent from each other, Dayal's presupposition states that only one of these propositions is true, i.e. only one boy and only one girl live together, correctly delivering the SP reading.

On the other hand, we propose that the PL denotation of (2a) looks like (4). The last proposition represents the possibility that all of the four individuals live together. We will discuss how to exclude this possibility (using max), but whether it is present or not, Dayal's presupposition allows multiple pairs to live together.

We adopt Winter's (2001) theory of plurality to derive these denotations compositionally. It is assumed that distributive predicates like *smoke* and singular nouns are of type *et*, while collective predicates like *live together* are of type $(et)t$. The sole meaning of *and* is Boolean meet $\sqcap$. This straightforwardly derives the distributive reading of conjoined singular quantifiers (e.g. *a boy and a girl*):

(5) a. $[\![\text{a boy}]\!] = \lambda P_{et}.\ \exists x \in \mathsf{BOY}_w(P(x))$ b. $[\![\text{a girl}]\!] = \lambda P_{et}.\ \exists x \in \mathsf{GIRL}_w(P(x))$
c. $[\![\text{a boy and a girl}]\!] = [\![\text{a boy}]\!] \sqcap [\![\text{a girl}]\!] = \lambda P_{et}.\ \exists x \in \mathsf{BOY}_w \exists y \in \mathsf{GIRL}_w(P(x) \wedge P(y))$

In order to derive the collective reading, two type-shifting operations are employed:

(6) a. $\text{min} \coloneqq \lambda Q_{\tau t}.\lambda P_{\tau}.\ Q(P) \wedge \forall P'((Q(P') \wedge P' \subseteq P) \rightarrow P' = P)$
b. $\mathbb{E} \coloneqq \lambda P_{\tau t}.\lambda Q_{\tau t}.\ \exists X_{\tau}(P(X) \wedge Q(X))$

In terms of sets, min takes a set Q of predicates and returns the minimal elements in Q with respect to $\subseteq$. $\mathbb{E}$ existentially quantifies over these minimal elements, deriving the collective reading

(7) $\mathbb{E}(\text{min}([\![\text{a boy and a girl}]\!]))([\![\text{live together}]\!]) = \exists S \in \{\{x,y\} \mid x \in \mathsf{BOY}_w \wedge y \in \mathsf{GIRL}_w\}(S \in \mathsf{LT}_w)$

We take *wh*-phrases to denote existential quantifiers carrying the feature [WH], and the question operator $?_p$ is interpreted as (9) (cf. Karttunen 1977):

(8) $[\![\text{which}]\!] = [\![\text{a}]\!] = \lambda Q_{et}.\lambda P_{et}.\ \exists x(P(x) \wedge Q(x))$ (9) $[\![?_p]\!] = \lambda q_{st}.\ p = q$

With these ingredients, the SP reading (3) of (2a) is straightforwardly derived from the following LF:

(10) λp [[$\mathbb{E}$[min [which boy and which girl]]] [λx [$?_p$ [t_x live together]]]]

We propose that the PL reading (4) requires insertion of the covert distributivity operator $\mathbb{D}$:

(11) $\mathbb{D} \coloneqq \lambda Q_{\tau t}.\lambda P_{\tau t}.\ P \neq \varnothing \wedge P \subseteq Q$

The PL reading is derived with the LF in (12), which differs from (10) in containing two occurrences of $\mathbb{D}$.

(12) λp [[$\mathbb{E}$[$\mathbb{D}$ [min [which boy and which girl]]]] [λx [$?_p$ [t_x [$\mathbb{D}$ live together]]]]]

Recall now that the PL reading is relatively latent. Our analysis accounts for this observation with an auxiliary assumption that insertion of $\mathbb{D}$ is costly (in the absence of morphological marking).

Turning now to distributive predicates like (2b), our analysis so far predicts the same ambiguity with distributive predicates too. In particular, we predict the unavailable PL reading with the following LF.

(13) λp [[$\mathbb{E}$[$\mathbb{D}$[min[which boy and which girl]]]] [λx[$?_p$[t_x[$\mathbb{D}$[$\mathbb{D}$ smoke]]]]]]

In order to block this reading, we postulate a constraint banning stacking of $\mathbb{D}$. As we will argue in the talk, this constraint is independently necessary under the theory of plurality we adopt here.

Notice that under our analysis, the PL reading of conjoined singular *which*-phrases is due to hidden plurality/distributivity. This is different from how the PL reading of more canonical examples such as (1) is analysed. There is reason to believe that the PL reading of conjoined singular *which*-phrases and that of (1) are of a different nature. That is, the two *which*-phrases in (1) are known to be asymmetric in that the boys need to be all mentioned in a complete answer, while the girls need not be. By contrast, we do not observe such an interpretive asymmetry for the PL reading of (2a).

References: Veneeta Dayal. 1996. *Locality in Wh Quantification: Questions and Relative Clauses in Hindi*. Kluwer, Dordrecht. Lauri Karttunen. 1977. Syntax and semantics of questions. *Linguistics and Philosophy*, 1:3–44. Yoad Winter. 2001. *Flexibility Principles in Boolean Semantics: The Interpretation of Coordination, Plurality, and Scope in Natural Language*. MIT Press, Cambridge, MA.