# Cumulative questions and structured witnesses

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# Pair-list readings of *wh* plus definite plurals

- Questions with plural arguments allow *pair-list* readings.

(1) a. Who do the students like?

b. Ann likes Professor Jones and Ben likes Professor Smith.

- It is controversial whether this is semantically defined ‘answer’ or pragmatically enriched ‘response’.
  - Krifka (1992); Srivastav (1992): the denotation of (1a) is *cumulative*,
  - i.e. (1a) asserts that there exists a correspondence between the students and those who they like, but underspecifies which correspondence holds.

# The cumulation-and-elaboration hypothesis

- (2c) shows the denotation with the **-operator (Sauerland, 1998; Beck, 2000; Beck and Sauerland, 2000, a.o.) of (2b) when Prof. Jones and Prof. Smith are the ones that the students like.

(2) a. $[\![\text{R**}]\!] = \lambda X \lambda Y \, \forall x \in X \rightarrow \exists y \in Y \, [\text{R}(x)(y)] \, \& \, \forall y \in Y \rightarrow \exists x \in X \, [\text{R}(x)(y)]$

b. [who $\lambda_{x_1}$ the students **(like) $x_1$ ]

c. $[\![\text{(2b)}]\!] = \{\forall x \in \{z : z \in [\![\text{the student}]\!]\} \rightarrow \exists y \in \{\text{Jones,Smith}\} \, [\text{R}(x)(y)] \, \& \, \forall y \in \{\text{Jones,Smith}\} \rightarrow \exists x \in \{z : z \in [\![\text{the student}]\!]\} \, [\text{R}(x)(y)]\}$

- The denotation of (1a) is too weak to request pair-list answers.
- And yet, it is reasonable to assume that the addressee may offer more information than is required, e.g., clarification of who likes whom is over-informative, but still natural.

# Against the cumulation-and-elaboration hypothesis

- Although this analysis is theoretically parsimonious, Johnston (2023) convincingly argues that this should not be the case.
- He shows that (3b) can be asked even though the context already entails an existence of player-number correspondence.

(3) Scenario: The head coach of a basketball team had five jerseys made, numbered 1-5, for the five players on the team. Each player chose a jersey. The assistant coach knows all five players on the team, knows the numbers that were available, and believes that each of those players chose exactly one jerseys. However, the assistant coach was not present for the choosing, and so doesn't yet know which player selected which jersey.

a. #Who are the players?

b. Which numbers did the players pick? (Johnston, 2023)

# Deriving pair-list readings with the distributivity operator

- Thus, Johnston (2023) argues that a pair-list answer should be semantically enabled in the denotation of (3b).
- He proposes that definite plurals may perform distributive quantification with the covert **Dist(ributivity) operator**.
- i.e. a covert version of the adverbial "each" and it has been independently modtivated in the literature.
- This derives a pair-list reading on a par with a pair-list reading with distributive quantifiers.

# Number-(in)sensitivity of pair-list readings

- His analysis is also parsimonious in the sense that it only relies on an independently motivated ingredient, namely the Dist operator.
  - However, his analysis raises a problem with respect to difference between distributive quantifiers and definite plurals.
  - Especially, Johnston (2023) himself mentions the number sensitivity of *wh* questions with definite plurals.
  - In contrast, *wh*-questions with distributive quantifiers do not show such number-sensitivity.

# Number-(in)sensitivity of pair-list readings.Cont

(4) Which **professors** do the students like?
   a. They like Professor Jones and Professor Smith.
   b. Ann likes Professor Jones, and Ben likes Professor Smith.

(Johnston, 2023)

(5) Which **professor** do the students like?
   a. They like Professor Jones.
   b. # Ann likes Professor Jones, and Ben likes Professor Smith.

(Johnston, 2023)

(6) Which **professor** does every student like?
   a. Every student likes Professor Jones.
   b. Ann likes Professor Jones, and Ben likes Professor Smith.

(Johnston, 2023)

# The objective

- Johnston (2023) explains the core data by assimilating definite plurals to distributive quantifiers with the Dist operator.
  - However, this blurs their distinction in terms of number sensitivity.
- In this talk, I propose an alternative with a *structured witness set*:
  - the speaker requests the witness of $wh$-variable including how its value corresponds to the values of other variables.
  - The idea is that pluralities and quantification both semantically enable pair-list answers via different paths.
  - The resultant analysis makes better predictions about co-variability of materials below definite plurals and quantifiers.

# Disclaimers

- As a proof of the concept, I illustrate an implementation with a simple partition semantics with *Dynamic Plural Logic* (DPIL) (van den Berg, 1996, *et seq*).
  - However, its full-fledged version is implemented with *Dynamic Inquisitive Semantics* (Dotlačil and Roelofsen, 2019, 2021; Roelofsen and Dotlačil, 2023).
- This extension analyses questions with multiple *wh*-expressions differently from Dotlačil and Roelofsen (2021); Roelofsen and Dotlačil (2023).

# Roadmap

# Discourse storage of anaphoric information

- A *discourse referent* (dref), e.g., $u_1$, $u_2$,..., functions as an address in which some values are stored, i.e. variables.
- I take a context as a set of *information states*, $g$, $i$, $h$,..., which assign some values to drefs, i.e. variable assignments.
  - Information states keep track of what entities have been mentioned at the current discourse.

| | $u_1$ | $u_2$ | $u_3$ | ... |
|---|---|---|---|---|
| $g$ | Aki | Bede | Chris | ... |

| | $u_1$ | $u_2$ | $u_3$ | ... |
|---|---|---|---|---|
| $i$ | Daiki | Elin | Fred | ... |

| | $u_1$ | $u_2$ | $u_3$ | ... |
|---|---|---|---|---|
| $h$ | Greg | Hannah | Irene | ... |

Table: Drefs and information states

# Discourse storage of quantificational dependencies

- I adopt an enriched data structure so that it keeps track of not only values of drefs, but also **dependencies** among drefs.
  - I adopt *plural information states* (PIS), i.e. sets of information states (van den Berg, 1996; Nouwen, 2007; Brasoveanu, 2008, a.o.).

| $G$ | $u_1$ | $u_2$ | $u_3$ | ... |
|---|---|---|---|---|
| $g_1$ | Aki | David | Greg | ... |
| $g_2$ | Bede | Elin | Hannah | ... |
| $g_3$ | Chris | Fred | Irene | ... |
| ... | ... | ... | ... | ... |

Table: Plural information states

- One may obtain pluralities as a cross-assignment sum.
  - $G(u)$ is an abbreviation of $\{g(u) : g \in G\}$.

# Dependencies

- $u_m$ is **dependent** on $u_n$ iff change of the value of $u_m$ may result in change of the value of $u_n$ (*co-variation*).
- For example, $u_2$ and $u_3$ are dependent on $u_1$, but $u_4$ is not.

| $H$ | $u_1$ | $u_2$ | $u_3$ | $u_4$ |
|---|---|---|---|---|
| $h_1$ | $a$ | $x_2$ | $x_3$ | $x_4$ |
| $h_2$ | $b$ | $y_2$ | $x_3$ | $x_4$ |
| $h_3$ | $c$ | $z_2$ | $z_3$ | $x_4$ |

Table: Dependency and co-variation

- The definition of dependencies is given in (7b).

(7) a. $G_{u_n=d} = \{g : g \in G \,\&\, g(u_n) = d\}$

b. In a plural information state $G$, $u_m$ is dependent on $u_n$ iff $\exists d, e \in G(u_n)\,[G_{u_n=d}(u_m) \neq G_{u_n=e}(u_m)]$ (van den Berg, 1996)

# DPIL assignment extension

- I use the term *assignment extension* to the process in which a new value is assigned to a dref.
  - The basic assignment extension is defined in (8)

(8) $g[u_n]h = \forall u[u \neq u_n \rightarrow g(u) = h(u)]$

  - i.e. $g$ and $h$ assign the same values to all the drefs except $u_n$.
  - I assume total assignments and put aside the issues with them.
- I adopt the definition of plural assignment extension that may introduce new dependencies.

# Dependency introduction

| $G$ | $u_1$ |
|---|---|
| $g_1$ | $x_1$ |
| $g_2$ | $x_2$ |

$\xrightarrow[G[u_2]H]{}$

| $H$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_1$ | $x_1$ | $y_1$ |
| $h_2$ | $x_2$ | $y_2$ |

Table: Dependent

| $G$ | $u_1$ |
|---|---|
| $g_1$ | $x_1$ |
| $g_2$ | $x_2$ |

$\xrightarrow[G[u_2]H]{}$

| $H$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_1$ | $x_1$ | $y_1$ |
| $h_2$ | $x_1$ | $y_2$ |
| $h_3$ | $x_2$ | $y_1$ |
| $h_4$ | $x_2$ | $y_2$ |

Table: Independent

- Assignment extension with plural information states is defined as the point-wise generalisation of (8) as shown in (9).
  - The point-wise addition of new values is satisfied in the both of the contexts above.

(9) $G[u]H \Leftrightarrow$
$\forall g\,[g \in G \rightarrow \exists h\,[h \in H \,\&\, g[u]h]] \,\&\, \forall h\,[h \in H \rightarrow \exists g\,[g \in G \,\&\, g[u]h]]$

# GSV/Heimian update

- I will build a simple question semantics on DPIL.
  - First, I take a context as a set of *possibilities*, which are pairs of a possible world and a plural information state.
  - A formula denotes a function from the input context to the output context.
- The sequencing operator ; signals dynamic conjunction.

(10) $c[\phi;\psi] = c[\phi][\psi]$

- Assignment extension is refined as (11).

(11) $c[u] = \{\langle w, H\rangle : \exists G\,[\langle w, G\rangle \in c \,\&\, [\forall g \in G\, \exists h \in H\,[g[u]h] \,\&\, \forall h \in H\, \exists g \in G\,[g[u]h]]]\}$

# Lexical relations and (non-atomicity)

- Lexical relations are evaluated distributively as default and the (non-)atomicity condition is defined collectively (Brasoveanu, 2008).

(12) $c[R(u_1, ..., u_n)] =$
$\{\langle w, G\rangle : \langle w, G\rangle \in c \,\&\, \forall g \in G[\langle g(u_1), ..., g(u_n)\rangle \in I_w(R)]\}$

(13) a. $\text{Atom}(x) \Leftrightarrow \forall y[y \subseteq x \rightarrow y = x]$

b. $c[\text{atom}(u)] = \{\langle w, G\rangle : \langle w, G\rangle \in c \,\&\, \text{Atom}(G(u))\}$

c. $c[\text{non-atom}(u)] = \{\langle w, G\rangle : \langle w, G\rangle \in c \,\&\, \neg\text{Atom}(G(u))\}$

# Distributivity

- The dynamic distributivity operator $\delta$ (van den Berg, 1996; Brasoveanu, 2008, a.o.) is defined in (14).

(14) $c[\delta_{u_n}(\phi)] = \{\langle w, H\rangle : \exists G\,[\langle w, G\rangle \in c \,\&\, G(u_n) = H(u_n)\,\&$
$\forall d \in G(u_n)\,[G_{u_n=d} \in c \,\&\, H_{u_n=d} \in c[\phi]]]\}$

  - $\delta_{u_n}$ evaluate $\phi$ with respect to each $G_{u_n=d}$.

| $G$ | $u_1$ |
|---|---|
| $g_1$ | $x_1$ |
| $g_2$ | $x_1$ |
| $g_3$ | $x_2$ |
| $g_4$ | $x_3$ |
| $g_5$ | $x_3$ |

$\xrightarrow{\delta_{u_1}}$

$\xrightarrow[u_2]{}$

| $H_{u_1=x_1}$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_1$ | $x_1$ | $y_1$ |
| $h_2$ | $x_1$ | $y_1$ |

$\xrightarrow[u_2]{}$

| $H_{u_1=x_2}$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_3$ | $x_2$ | $y_2$ |

$\xrightarrow[u_2]{}$

| $H_{u_1=x_3}$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_4$ | $x_3$ | $y_3$ |
| $h_5$ | $x_3$ | $y_3$ |

$\xrightarrow[u_2]{}$

| $H$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_1$ | $x_1$ | $y_1$ |
| $h_2$ | $x_1$ | $y_1$ |
| $h_3$ | $x_2$ | $y_2$ |
| $h_4$ | $x_3$ | $y_3$ |
| $h_5$ | $x_3$ | $y_3$ |

Table: Distributive update on the subsets of plural information states

# The witness requesting operator

- As a crucial ingredient, I borrow the witness requesting operator $?u$ (Dotlačil and Roelofsen, 2021; Roelofsen and Dotlačil, 2023).
  - It raises a new issue regarding the value of $u$.

(15) $c[?u] = \{s \subset c : \exists x_e \forall \langle w, G \rangle \in s \exists \langle w', G' \rangle \in c\, [w = w' \,\&\, \forall g' \in G'\, [g'(u) = x]]\}$

  - The context is split into several sets of possibilities $s$ along with the value of $u$, e.g., a (downward closed) set of possibilities where $x = a$ and another (downward closed) set of possibilities where $x = b$.
  - I call those (downward closed) sets of possibilities *inquisitive states*.
- An *issue* $I$ is a non-empty, downward closed set of inquisitive states, and an inquisitive state $s$ *resolves* an issue $I$ iff $s \in I$

# The status quo: dependency-insensitivity

- At this point, the $?u$ operator only cares about the value of $u$ and does not discriminate different ways to distribute values across members of a plural information state.
  - e.g., in (3), there can be only one set of possibilities in which $x$ is the sum of five numbers.
  - Thus, this version of $?u$ cannot raise an issue about the exact number-player correspondence in (3b).
- I propose the **structured witness requesting** operator $?u*$, a refined version of $?u$ operator that is sensitive to dependencies $u$ participates with respect to other drefs.

# Structured witness sets

- I define the structured witness requesting operator as (33).

(16) $c[?u*_{u_n}] = \{s \subset c : \exists f_{\langle e,e\rangle} \forall \langle w, G\rangle \in s \exists \langle w', G'\rangle \in c\, [w = w'\ \&$
$\forall d \in G(u_n)\, [f(d) = G_{u_n=d}(u)]]\}$

- (33) partitions the context based on a function $f$ and it is equivalent to (15) when $G$ is a singleton set of variable assignments.
  - If $G$ is non-singleton, (33) distinguishes two possibilities that agree on the value of $G(u)$ but disagree on how its value is distributed across the members of $G$.
  - Thus, each $s$ in $c$ expresses different dependencies with respect to the value of $u$.

# Providing dependency structures

- Let's see how $?u*$ derives pair-list answers with plural $wh$ and definite plurals.
  - I assume that the $?u*$ operator is introduced at the left-periphery (Dotlačil and Roelofsen, 2021; Roelofsen and Dotlačil, 2023).
  - However, see Appendix I for a motivation to hard-wire it instead to $wh$-expressions, and Appendix II for its repercussions.

# Plural *wh* and definite plural

(17) Which **professors** do the students like?

a. the students$^{u_1}$ like which$^{u_2}_{u_1}$ professors

b. $c[u_1$;student$(u_1)$;non-atom$(u_1); u_2$;professor$(u_2)$;non-atom$(u_2)$; like$(u_1, u_2); ?u_{2*u_1}]$

- (17b) partitions the context based on possible functional dependencies between the students and the professors.
  - The output is a set of inquisitive states each of which agree with the values of $u_1$ and $u_2$, and the correspondence between them.
  - Consider four possibilities $\langle w_1, G\rangle$, $\langle w_2, G'\rangle$, $\langle w_3, G''\rangle$ and $\langle w_4, G'''\rangle$.

# Plural *wh* and definite plural.Cont

| $\langle w_1, G\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g_1$ | Ann | Jones |
| $g_2$ | Ben | Smith |

| $\langle w_3, G''\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g''_1$ | Ben | Jones |
| $g''_2$ | Ann | Smith |

| $\langle w_2, G'\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g'_1$ | Ben | Smith |
| $g'_2$ | Ann | Jones |

| $\langle w_4, G'''\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g'''_1$ | Ann | Smith |
| $g'''_2$ | Ben | Smith |

Table: Dependencies stored in possibilities

- $c = \{s_1, s_2\}$ such that $s_1 = \{\langle w_1, G\rangle, \langle w_2, G'\rangle\}$, and $s_2 = \{\langle w_3, G''\rangle\}$.
  - Crucially, {⟨Ann, Jones⟩,⟨Ben, Smith⟩} and {⟨Ann, Smith⟩,⟨Ben, Jones⟩} are two distinct answers.
  - This means that (17b) semantically derives pair-list answers.
  - Note that $\langle w_4, G'''\rangle$ is discarded: $G'''(u_2)$ is singular and thus it violates the condition non-atom($u_2$).

# Singular *wh* and definite plural

- On this point, it is important that the $?u{*}_{u_n}$ operator itself does not perform distributive quantification.
  - Consider the example (18).
  - In this case, [[which professor]] only introduces a singular value to $u_2$ simply because it is singular.
  - By definition, there is no possibility that $u_2$ co-varies with $u_1$.

(18) Which **professor** do the students like?

a. the students$^{u_1}$ like which$^{u_2}$ professor

b. $c[u_1$;student$(u_1)$;non-atom$(u_1)$; $u_2$,professor$(u_2)$;atom$(u_2)$; like$(u_1, u_2)$; $?u_2{*}_{u_1}]$

# Singular *wh* and definite plural.Cont

- Since atom($u_2$), only $G'''$ is compatible with (18b).
  - i.e., only $s_3 = \{\langle w_4, G''' \rangle\}$ may resolve the issue raised by (18).
  - Thus, (18) lacks pair-list answers.

| $\langle w_1, G \rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g_1$ | Ann | Jones |
| $g_2$ | Ben | Smith |

| $\langle w_3, G'' \rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g_1''$ | Ben | Jones |
| $g_2''$ | Ann | Smith |

| $\langle w_2, G' \rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g_1'$ | Ben | Smith |
| $g_2'$ | Ann | Jones |

| $\langle w_4, G''' \rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g_1'''$ | Ann | Smith |
| $g_2'''$ | Ben | Smith |

Table: Dependencies stored in possibilities

- The situation is different if the subject is a quantifier because it introduces its own $\delta$ operator.

# Singular *wh* and quantifiers

- I simplify the content of dynamic generalised quantification (see van den Berg, 1996; Brasoveanu, 2007, for more details).

(19) Which **professor** does **every** student like?

a. every student$^{u_1}$ like which$^{u_2}$ professor

b. $c[u_1$;non-atom$(u_1)$;$\delta_{u_1}($student$(u_1)$;$u_2$;professor$(u_2)$;atom$(u_2)$; like$(u_1,u_2))$;$?u_{2*u_1}]$

- In (19b), the value of $u_2$ is constrained to be singular just like it is in (18b), but it is under the scope of $\delta$ in (19b).
  - As a result, this atomicity constraint is evaluated with respect to each subset of information states, i.e. $G_{u_1=d}$, and $u_2$ may still have plural values under the sum of those subsets, i.e. $G$.
  - This 'neutralisation' of atomicity is reminiscent of DPIL-accounts of *quantificational subordination* (van den Berg, 1996, *et seq*).

# Singular *wh* and quantifiers.Cont

- All the four possibilities are compatible with this requirement and thus all of $s_1$, $s_2$ and $s_3$ may resolve the issue raised by (19).
  - Thus, (19b) also semantically derives pair-list answers.

| $\langle w_1, G\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g_1$ | Ann | Jones |
| $g_2$ | Ben | Smith |

| $\langle w_3, G''\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g_1''$ | Ben | Jones |
| $g_2''$ | Ann | Smith |

| $\langle w_2, G'\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g_1'$ | Ben | Smith |
| $g_2'$ | Ann | Jones |

| $\langle w_4, G'''\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g_1'''$ | Ann | Smith |
| $g_2'''$ | Ben | Smith |

Table: Dependencies stored in possibilities

- Note that $s_4 = \{\langle w_4, G'''\rangle\}$ is not discarded this case.
  - It predicts that "Ann likes Prof. Smith and Ben likes Prof. Smith, too." is a legit answer to this question.

# Taking Stock

- I proposed a structured witness requesting operator $?u*$ operator.
  - $?u*$ is associated with its antecedent and partitions the context based on a function from the value of its antecedent to the value of the $wh$-dref.
  - This derives pair list readings when the context stores quantificational dependencies between two drefs, which can be achieved by a plural $wh$ or a singular $wh$ under the scope of $\delta$.
- The most crucial aspect of this analysis is that the $\delta$ operator is not necessary to derive a pair-list reading with $wh$ plus definite plurals, which naturally accounts for its number sensitivity.

# Comparison with Xiang (2023)

- Xiang (2023) has a similar criticism on Johnston (2023) and proposes a dependency-based analysis.
  - Her analysis is couched in a static framework and dependency is established via the covert Resp operator (Gawron and Kehler, 2004).
  - Here, $g$ is a pragmatically available sequencing function.

(20) $\text{Resp}_g = \lambda P \lambda x \forall n [1 \leq n \leq |g| \rightarrow [g(P)(n)](g(x)(n))]$
(The $n$-th part of the property $P$ holds for the $n$-th part of the individual $x$)

  - The Resp operator occurs between the trace of a definite plural and the predicate combined with the functional trace of $wh$.

(21) [ which numbers $\lambda i$ [ $\lambda w$ the players $\lambda j$ [ $x_j$ **Resp** picked$_w$-$f_i(x_j)$ ] ] ]

# Objection 1: distribution of “respectively”

- The Resp operator is originally proposed for respective predication.

(22) Tolstoy and Dostoyevsky wrote Anna Karenina and The Idiot, respectively. (Gawron and Kehler, 2004)

- However, two definite plurals cannot enter into respective predication unless their cardinality is specified (cf. Kubota and Levine, 2016).

(23) a. *The players picked the numbers, respectively.
b. The five players picked the five numbers, respectively.

- Furthermore, a plural *wh* and a definite plural cannot enter into respective predication, either.

(24) *Which numbers did the players pick, respectively?

- This is problematic for the Resp-based approach if the Resp operator is taken as a covert version of “respectively.”

# Objection 2: co-variation of indefinites

- Recall that the Resp operator takes the property $P$ under the scope of universal quantification.

(20) $\text{Resp}_g = \lambda P \lambda x \forall n [1 \leq n \leq |g| \rightarrow [g(P)(n)](g(x)(n))]$

- In contrast, the DPIL approach does not involve quantification below the definite plural.
- In general, co-varying interpretations of a singular indefinite is harder with non-quantificational plural arguments (see Dotlacil, 2010, for an experimental result).
- Thus, Xiang (2023) predicts that the co-varying interpretation of a singular indefinite is readily available with *wh* plus definite plurals.
- On the other hand, the DPIL approach predicts that the co-varying interpretation of a singular indefinite is dispreferred.

# Objection 2: co-variation of indefinites.Cont

(25) Which cities did the guides recommend to a customer?

a. * Guide A recommended Amsterdam to Ann, Guide B recommended Utrecht to Bill and Guide C recommended Leiden to Chris

b. All the guides recommended a city to Ann. Guide A recommended Amsterdam to Ann, Guide B recommended Utrecht to Ann and Guide C recommended Leiden to Ann.

(26) a. A: Which cities did the guides recommend to customers?

b. B: Guide A recommended Amsterdam to Ann, Guide B recommended Utrecht to Bill and Guide C recommended Leiden to Chris

(27) a. A: Which city did every guide recommend to a customer?

b. B: Guide A recommended Amsterdam to Ann, Guide B recommended Utrecht to Bill and Guide C recommended Leiden to Chris

# Objection 2: co-variation of indefinites.Cont

- The co-variation reading is possible with *wh* plus a quantifier, but not with *wh* plus definite plurals.
  - This favours the DPIL approach.
- However, pair-list readings with a singular indefinite are degraded in the context in which the questioner already knows the witness of *wh*.
  - Johnston (2023); Xiang (2023) cannot say that insertion of a covert operator is blocked when the speaker knows the witness of *wh*.
  - If so, they lose an account for (3b).
  - I have to say that dependency-storage with a singular indefinite is blocked when the speaker already knows the witness of *wh*.
  - I have to work it out to make this argument complete.

# Caution on the covert Dist

- Note that my claim is that insertion of the Dist operator is a dispreferred option and **not** that insertion of the Dist is impossible.
  - Indeed, one of my informants reported that they accept
  - (i) co-variation of a singular indefinite under a definite plural, and
  - (ii) a pair-list answer to a singular *wh* with a definite plural.
  - This is exactly what Johnston (2023) should predict.
  - As long as insertion of Dist is ‘costly’, this is not a problem.

# Caution on the covert Dist.Cont

- However, there are cases in which Dist is rather preferred.
  - I thank to Patrick Elliot for discussions.

(28) The children are singing or dancing.
**True** if Child 1 and Child 2 are singing, and Child 3 is dancing.

  - Possibly, disjunction is the culprit?
  - e.g., the parse without Dist requires an additional epistemic uncertainty while one with Dist does not.
  - In any case, it should be further explored when insertion the Dist operator is motivated.
- As long as there are speakers whose judgements pattern with those reported in this talk, Johnston (2023) makes wrong predictions and the proposed analysis makes right predictions.

# Conclusion

- I proposed a dynamic plural question semantics with the structured witness requesting operator $?u*$.
  - This derives pair-list readings of *wh* plus definite plurals without assimilating definite plurals with distributive quantifiers.
  - This accounts for the number sensitivity of *wh*-expressions and co-varying readings of intervening singular indefinites.

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Thank you!

# Dynamic Plural Inquisitive semantics

- Basic types: type $t$ for truth values, type $w$ for possible worlds, type $e$ for individuals, type $\pi$ for drefs.
  - An information state $g$ is a function of type $\langle \pi, e \rangle$.
  - A plural information state (PIS) $G$ is a set of variable assignments with type $\langle \langle \pi, e \rangle, t \rangle$. I abbreviate $\langle \langle \pi, e \rangle, t \rangle$ with $m$
  - A possibility $p$ is a pair of a possible world and a PIS with type $\langle w \times m \rangle$.
  - An inquisitive state $s$ is a set of possibilities with type $\langle w \times m, t \rangle$.
  - Context $c$ is a set of inquisitive states with type $\langle \langle w \times m, t \rangle, t \rangle$.
  - I use the *meta-type* $T$ as an abbreviation of $\langle \langle \langle w \times m, t \rangle, t \rangle, \langle \langle w \times m, t \rangle, t \rangle \rangle$, which is a function from a context to a context.

# Dynamic Plural Inquisitive semantics.Cont

(29) Assignment extension:
$c[u] = \{s : \exists s' \in c\,[\forall \langle w, G\rangle \in s\, \exists \langle w', H\rangle \in s'\,[w = w' \,\&\, G[u]H] \& \forall \langle w, G\rangle \in s'\, \exists \langle w, H\rangle \in s\,[w = w' \,\&\, G[u]H]]\}$

(30) Evaluation of lexical relation:
$c[R(u_1, ..., u_n)] = \{s :\ s \in c \,\&\, \forall \langle w, G\rangle \in s\, \forall g \in G[\langle g(u_1), ..., g(u_n)\rangle \in I_w(R)]\}$

(31) (Non-)atomicity conditions

a. Atom$(x) \Leftrightarrow \forall y[y \subseteq x \rightarrow y = x]$

b. $c$[atom$(u)$] $= \{s :\ s \in c \,\&\, \forall \langle w, G\rangle$ [Atom$(G(u))$]$\}$

c. $c$[non-atom$(u)$] $= \{s :\ s \in c \,\&\, \forall \langle w, G\rangle[\neg$Atom$(G(u))]\}$

(32) The $\delta$ operator:
$c[\delta_{u_n}(\phi)] = \{s : \exists s' \in c\,[\forall \langle w, G\rangle \in s'\, \exists \langle w', H\rangle \in s\,[w = w' \,\&\, G(u_n) = H(u_n) \,\&\, \forall d \in G(u_n)\,[\{\langle w, G_{u_n = d}\rangle\} \in c \,\&\, \{\langle w', H_{u_n = d}\rangle\} \in c[\phi]]]]]\}$

(33) The structured witness requesting operator (*to be revised*):
$c[?u{*}_{u_n}] = \{s \in c :\ \exists f_{\langle e,e\rangle}\, \forall \langle w, G\rangle \in s\, \exists \langle w', G'\rangle \in \cup c\,[w = w' \,\&\, \forall d \in G(u_n)\,[f(d) = G_{u_n = d}(u)]]\}$

# Dynamic Plural Inquisitive semantics.Cont

(34) a. $\exists u = \lambda c_{\langle\langle s\times m,t\rangle,t\rangle}\lambda s_{\langle s\times m,t\rangle}\, s \in c[u]$

b. $\mathrm{R}\{u_1\}...\{u_n\} = \lambda c_{\langle\langle s\times m,t\rangle,t\rangle}\lambda s_{\langle s\times m,t\rangle}\, s \in c[\mathrm{R}(u_1)...(u_n)]$

(35) a. $[\![\text{professor}]\!] = \lambda v_{\pi}\,[\text{atom}\{u\}\,\&\,[\text{professor}\{v\}]$

b. $[\![\text{professors}]\!] = \lambda v_{\pi}\,[\text{non-atom}\{u\}\,\&\,[\text{professor}\{v\}]$

c. $[\![\text{like}]\!] = \lambda \mathrm{R}_{\langle \pi T,T\rangle}\lambda v_{\pi}\,\mathrm{R}(\lambda v'\,[\text{like}\{v'\}\{v\}])$

d. $[\![\text{a}]\!] = \lambda \mathrm{P}_{\langle \pi T\rangle}\,\mathrm{Q}_{\langle \pi T\rangle}\,[\exists u\,\&\,\mathrm{P}\{u\}\,\&\,\mathrm{Q}\{u\}]$

e. $[\![\text{it}_{u_n}]\!] = \lambda \mathrm{P}_{\langle \pi T\rangle}\,[\mathrm{P}\{u_n\}]$

(36) a. $[\![\text{who}_{u_n}]\!] = \lambda \mathrm{Q}_{\langle \pi T\rangle}\,[\exists u\,\&\,\text{Person}(u)\,\&\,\mathrm{Q}(u)\,\&\,?u{*}_{u_n}]$

b. $[\![\text{which}_{u_n}]\!] = \lambda \mathrm{P}_{\langle \pi T\rangle}\,\mathrm{Q}_{\langle \pi T\rangle}\,[\exists u\,\&\,\mathrm{P}(u)\,\&\,\mathrm{Q}(u)\,\&\,?u{*}_{u_n}]$

# Subject-object asymmetry

(37) a. Which numbers did the players pick?

b. $\exists u_1$ & non-atom($u_1$) & players($u_1$) & $\exists u_2$ & non-atom($u_2$) & numbers($u_2$) & $?u_1 *_{u_2}$

(38) a. # Which players picked the numbers?

b. $\exists u_1$ & non-atom($u_1$) & players($u_1$) & $?u_1 *_{u_2}$ & $\exists u_2$ & non-atom($u_2$) & numbers($u_2$)

# Detour: partial plurality inference

- It is surely an over-simplification that the non-atomicity condition is hard-wired to plural "which."
  - Indeed, plural "which" gives rise to co-called **partial plurality inference**,
  - i.e. it suffices to have one pair in which the value of $wh$-dref is plural.
  - Again, I thank to Patrick Elliot for the data and discussion.

(39) a. Which professors does every student like?

b. Johannes likes Ad and Hans, Deborah likes Klaus and Hans, Matthew likes **Nathan**.

- Analogous observations have been made for bare plurals.
  - Plural pronouns may trigger partial plurality inferences as well.

# Detour: partial plurality inference.Cont

(40) a. Exactly one of these coats has **pockets**.

b. Every passenger of this flight lost their **suitcases**.

(Sudo, 2023)

(41) Context: There are ten PhD students in this department. This semester, seven of them wrote exactly one paper, while the other three students wrote more than one paper. They all submitted their papers to a journal.

a. Every PhD student$^{u_1}$ wrote (some) papers$^{u_2}$ in this semester.

b. They$_{u_1}$ each submitted {*it / **them**}$_{u_2}$ to a journal.

(Nakamura, under edition)

- Partiality follows if plurality inference is the result of pragmatic competition (Sudo, 2023, cf.).
- Felicity of partially plural pair-list answers calls for competition mechanism in the plural dynamic inquisitive setting.

# Anaphora across conjoined questions

- A plural dynamic inquisitive system is independently motivated with dependency sensitive anaphora across conjoined questions.
- I thank to Patrick Elliot for data and discussions.

(42) Plural dependent anaphora

a. Which boy$^{u_1}$ does each girl$^{u_1}$ like best? and did they$_{u_1}$ send them$_{u_2}$ a Valentine's card?

b. Rebecca likes Chris, and sent him a card and Claire likes Barry, but didn't.

(43) Telescoping

a. Which boy$^{u_1}$ does each girl$^{u_1}$ like best? and did she$_{u_1}$ send him$_{u_2}$ a Valentine's card?

b. Rebecca likes Chris, and sent him a card and Claire likes Barry, but didn't.

# Multiple $wh$ and sequence of $?u*$

(44) Which students[u1] likes which professors[u2]?

(45) $c[?u*_{u_n}] = \{s \in c : \exists f_{\langle e,e\rangle} \forall \langle w, G\rangle \in s \exists s' \in c [s \geq s' \,\&\, \exists \langle w', G'\rangle \in s' [w = w' \,\&\, \forall d \in G(u_n) [f(d) = G_{u_1=d}(u)]]]\}$

(46)
a. Given information states $g$, $g'$, $g'$ is an extension of $g$ iff $g \subset g'$
b. Given plural information state $G, G'$, $G'$ is an extension of $G$, i.e. $G' \geq G$, iff every $g' \in G'$ is an extension of some $g \in G$ and every $g \in G$ is extended by some $g' \in G$
c. Given possibilities $\langle w, G\rangle \langle w', G'\rangle$, $\langle w', G'\rangle$ is an extension of $\langle w, G\rangle$, i.e. $\langle w', G'\rangle \geq \langle w, G\rangle$, iff $w' = w$ and $G' \geq G$.
d. Given inquisitive states $s$, $s'$, $s'$ is an extension of $s$, i.e. $s' \geq s$, iff every possibility in $s'$ is an extension of some possibility in $s'$.

# Generalised witness requesting operator

(47) $c[?u_1 ... u_{n-1}, u_n] = \{s \subset c : \exists f_{(e^{n-1},e)} \forall \langle w, G\rangle \in s \, \exists \langle w', G'\rangle \in c \, [w = w' \,\&\, \forall g \in G \, [g(u_n) = f(g(u_1), ... g(u_{n-1}))]]\}$

(48) $c[?u_1, u_2] = \{s \in c : \exists f_{(e,e)} \forall \langle w, G\rangle \in s \, \exists \langle w', G'\rangle \in \cup c \, [w = w' \,\&\, \forall g \in G \, [g(u_2) = f(g(u_1))]]\}$

(49) $c[?u_1 *_{u_1}, ?u_2 *_{u_1}] = c[?u_1 *_{u_1}][?u_2 *_{u_1}]$

a. $c[?u_1 *_{u_1}] = c' = \{s \in c : \exists f_{\langle e,e\rangle} \forall \langle w, G\rangle \in s \, \exists s' \in c \, [s \subseteq s' \,\&\, \exists \langle w', G'\rangle \in s' \, [w = w' \,\&\, \forall d \in G(u_1) \, [f(d) = G_{u_1 = d}(u_1)]]\}$
$= \{s \in c : \exists f_{\langle e,e\rangle} \forall \langle w, G\rangle \in s \, \exists \langle w', G'\rangle \in \cup c \, [w = w' \,\&\, \forall d \in G(u_1) \, [f(d) = G_{u_1 = d}(u_1)]]\}$

b. $c'[?u_2 *_{u_1}] = \{s \in c : \exists f_{\langle e,e\rangle} \forall \langle w, G\rangle \in s \, \exists s' \in c \, [s \subseteq s' \,\&\, \exists \langle w', G'\rangle \in s' \, [w = w' \,\&\, \forall d \in G(u_1) \, [f(d) = G_{u_1 = d}(u_2)]]\}$

# Sequential issue-raising

| $\langle w_1, G\rangle$ | $u_1$ |
|---|---|
| $g_1$ | Ann |
| $g_2$ | Ben |

| $\langle w_3, G'\rangle$ | $u_1$ |
|---|---|
| $g'_1$ | Chris |
| $g'_2$ | Dan |

| $\langle w_2, G''\rangle$ | $u_1$ |
|---|---|
| $g''_1$ | Ben |
| $g''_2$ | Ann |

| $\langle w_4, G'''\rangle$ | $u_1$ |
|---|---|
| $g'''_1$ | Dan |
| $g'''_2$ | Chris |

Table: Raising issue with the first witness requesting operator

- $c' = \{s_1, s_2\}$, $s_1 = \{\langle w_1, G\rangle, \langle w_2, G''\rangle\}$ and $s_2 = \{\langle w_3, G'\rangle, \langle w_4, G'''\rangle\}$

# Sequential issue-raising.Cont

| $\langle w_1, G\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g_1$ | Ann | Jones |
| $g_2$ | Ben | Smith |

| $\langle w_3, G'\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g'_1$ | Chris | Freeman |
| $g'_2$ | Dan | McGregor |

| $\langle w_2, G''\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g''_1$ | Ben | Jones |
| $g''_2$ | Ann | Smith |

| $\langle w_4, G'''\rangle$ | $u_1$ | $u_2$ |
|---|---|---|
| $g'''_1$ | Dan | Freeman |
| $g'''_2$ | Chris | McGregor |

Table: Raising issue with the second witness requesting operator

- $c'' = \{s'_1, s'_2, s'_3, s'_4\}$, $s'_1 = \{\langle w_1, G\rangle\}$, $s'_2 = \{\langle w_2, G''\rangle\}$, $s'_3 = \{\langle w_3, G'\rangle\}$ and $s'_4 = \{\langle w_4, G'''\rangle\}$.
  - $s'_1$ and $s'_2$ are extensions of $s_1$.
  - $s'_3$ and $s'_4$ are extensions of $s_2$.
  - Each state stores a different functional correspondence between the values of $u_1$ and $u_2$.

# Cross-sentential multiple *wh*

(50) Sentence-internal multiple *wh*

a. Who$^{u_1}$ ate what$^{u_2}$?

b. Tom ate bitterballen, Émile ate boterham and Giorgio ate pizza.

(51) Cross-sentential multiple *wh*

a. Who$^{u_1}$ ate lunch in the cafe? and what$^{u_2}$ did **they**$_{u_1}$ eat?

b. Tom ate bitterballen, Émile ate boterham and Giorgio ate pizza.

- Just one generalised $?u$ has difficulty in deriving pair-list answer to a conjunction of two single-*wh* question.

# Ambiguity with cardinal modification

(52) Context: A basketball team's head coach had ten jerseys made, numbered 1-10. From these, each of the team's five players chose exactly two jerseys, an even-numbered jersey for home games and an odd-numbered jersey for away games. The assistant coach (the questioner) knows all five players, knows the numbers that were available, and believes that each player chose exactly two jerseys.

a. Which **two** numbers did the players pick?
b. Ann picked 1 and 10, Ben picked 2 and 3, Chris picked 4 and 7, Dan picked 5 and 6, Emma picked 8 and 9.

# Ambiguity with cardinal modification.Cont

(53) Context: A basketball team's head coach got out a large crate of jerseys with various numbers. From these, each of the team's five players chose exactly two jerseys, an even-numbered jersey for home games and an odd-numbered jersey for away games. The assistant coach (the questioner) knows all five players and believes that each player chose exactly two jerseys, but has no information about what jersey numbers were available.

a. Which **ten** numbers did the players pick?

b. i. They picked numbers 1-10.

   ii. Ann picked 1 and 10, Ben picked 2 and 3, Chris picked 4 and 7, Dan picked 5 and 6, Emma picked 8 and 9.

# Mereological plurals and static cumulativity

| $H$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_1$ | $x_1 + x_2$ | $y_1$ |
| $h_2$ | $x_3 + x_4$ | $y_2$ |
| $h_3$ | $x_5 + x_6$ | $y_3$ |

Table: A plural information state with mereological plurals

(54) $c[R(u_1, ..., u_n)] = \{s : s \in c \,\&\, \forall \langle w, G \rangle \in s\, [\langle G(u_1), ..., G(u_n) \rangle \in I_w({}^*R)]\}$

a. $R \subseteq {}^*R$

b. If $\langle a_1, ..., a_n \rangle \in {}^*R$ and $\langle b_1, ..., b_n \rangle \in {}^*R$, then $\langle a_1 + b_1, ..., a_n + b_n \rangle \in {}^*R$.

c. Nothing else is in ${}^*R$.

# Additional motivation: (non-)functionality

- An answer to plural $wh$ plus definite plural does not need to consist of one-to-one pairs.
  - (I thank to Patrick Elliot for raising this point and providing me with examples.)

(55) a. Which professors do the students like?
b. Johannes likes **Ad and Hans**, and Deborah likes Klaus. (Patrick Elliot p.c.)

  - With mereological plurals, $f$ is a function from $^*D$ to $^*D$

# Distributivity on the *wh* restrictor

(56) a. $[\![\text{which}^{SG}_{u_n}]\!] = \lambda \mathsf{P}_{\langle \pi T\rangle}\,\mathsf{Q}_{\langle \pi T\rangle}\,[\exists u \,\&\, \mathsf{P}(u) \,\&\, \text{atom}(u) \,\&\, \mathsf{Q}(u) \,\&\, ?u*_{u_n}]$

b. $[\![\text{which}^{PL}_{u_n}]\!] = \lambda \mathsf{P}_{\langle \pi T\rangle}\,\mathsf{Q}_{\langle \pi T\rangle}\,[\exists u \,\&\, \delta_u(\mathsf{P}(u)) \,\&\, \text{non-atom}(u) \,\&\, \mathsf{Q}(u) \,\&\, ?u*_{u_n}]$

(57) $c[\text{two}(u)] = \{s : s \in c \,\&\, \forall \langle w, G\rangle\,[|G(u)| = 2]$

(58) $[\![\text{which}^{PL}_{u_n}\text{ two numbers}]\!] =$
$\mathsf{Q}_{\langle \pi T\rangle}\,[\exists u \,\&\, \delta_u(\text{two}(u) \,\&\, \text{number}(u)) \,\&\, \text{non-atom}(u) \,\&\, \mathsf{Q}(u) \,\&\, ?u*_{u_n}]$

# Two parses with two types of PISs

| $H$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_1$ | $x_1 + x_2$ | $y_1$ |
| $h_2$ | $x_3 + x_4$ | $y_2$ |
| $h_3$ | $x_5 + x_6$ | $y_3$ |

Table: Pair-list parse

| $H$ | $u_1$ | $u_2$ |
|---|---|---|
| $h_1$ | $x_1 + x_2 + ... + x_{10}$ | $y_1 + ... + y_5$ |

Table: Cumulative parse