# A Hybrid Categorial Approach to Question Composition[1]

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## Introduction

- **The core issue: What does a question mean?**

| | |
|---|---|
| Categorial approaches: | $\lambda$-abstract |
| Hamblin-Karttunen Semantics: | set of propositions |
| Partition Semantics: | partition of possible worlds |

- **Goal**: Revive categorial approach and overcome its problems.
- **Roadmap:** §1 Why pursing categorial approach?
  §2 Problems with traditional categorial approaches
  §3 Proposal: A hybrid categorial approach
  §4 Coordinations of questions
  §5 Applications

## 1. Why pursing a categorial approach?

### 1.1. The original motivation: short answers in discourse

- Categorial approaches were originally motivated to capture the semantic relation between questions and short answers in discourse.

  (1) Who came?
  a. Jenny came. (full answer)
  b. Jenny. (short answer)

  It remains controversial whether a short answer in discourse is bare nominal or covertly clausal.
  - If it is **bare nominal**, it should be derivable from a question denotation.
  - If it is **covertly clausal**, it denotes a proposition and is derived by ellipsis. (Merchant 2005)

- Compare:
  - **Categorial approaches**:[2] The root denotation of a question is a $\lambda$-abstract. Short answers of a question are possible arguments of the $\lambda$-abstract denoted by this question.

    (2) a. $[\![\text{who came}]\!] = \lambda x[\mathit{hmn}(x).\mathit{came}(x)]$
    b. $[\![\text{who came}]\!]([\![\text{Jenny}]\!]) = \mathit{came}(j)$

  - **Hamblin/Karttunen Semantics** (Hamblin 1973, Karttunen 1977): The root denotation of a question is a set of propositions, each of which is a possible/true answer of this question. Short answers can only be derived by ellipsis.

    (3) $[\![\text{who came}]\!] = \{{}^\wedge\mathit{came}(x) : x \in \mathit{hmn}_@\}$

[1]This talk draws on my dissertation chapter 1. I am grateful to my committee members: Gennaro Chierchia, Danny Fox, and C.-T. James Huang. For helpful comments and discussions, I thank Floris Roelofsen, Benjamin Spector, and the audiences at the Compositionality Workshop of GLOW 40 and the Linguistics & Philosophy Workshop at University of Chicago.

[2]Representatives of categorial approaches include Hausser & Zaefferer (1979), Hausser (1983), Von Stechow & Zimmermann (1984), Jacobson (1995, 2016), Guerzoni & Sharvit (2007), Ginzburg & Sag (2000), and among many others.

### 1.2. New evidence for categorial approach

- This talk doesn't take a position on the treatment of short answers in discourse. The following sections present two independent arguments for categorial approach.

#### 1.2.1. Caponigro's generalization on questions and free relatives (FRs)

- A *wh*-FR refers to the bare nominal meaning of a short answer of the corresponding *wh*-question.

(4) a. Mary ate [what Jenny bought].
  b. John went to [where he could get help].

- **Caponigro's Generalization** (Caponigro 2003, 2004): If a language uses the *wh*-strategy to form both questions and FRs, the *wh*-words found in FRs are always a **subset** of those found in questions.[3]

(5) Spanish *qué* 'what'

a. Pregunté **qué**/ lo-que cocinaste.
asked.1SG what/ the.N.S-COMP cooked.2SG
'I asked what you cooked.'

b. Comí ***qué**/ lo-que cocinaste.
ate.1SG *what/ the.N.S-COMP cooked.2SG
'I ate what you cooked.'

**Plausible explanation:** *Wh*-FRs are formed out of *wh*-questions. (Chierchia & Caponigro 2013)

$$\text{Questions} \xrightarrow{\text{Partial Op}} \text{Free relatives}$$

☞ The nominal meaning of a short answer must be derivable from the root denotation of a question.

#### 1.2.2. Quantificational variability effects

- Indirect questions with quantity adverbials (e.g., *mostly, for the most part, to a large extent*) are subject to quantificational variability (QV) effects (Berman 1991, Lahiri 2002, Beck & Sharvit 2002):

(6) Jenny mostly knows [$_{\text{Q}}$ who came]. $\rightsquigarrow$ Most $x$ [$x$ came] [J knows that $x$ came]

Typically, the domain restriction of the quantity adverbial can be formed by **atomic short answers** or **atomic propositional answers** of the embedded question. (Lahiri 1991, 2002; Cremers 2016)

(6′) ($w$: *Among the four considered individuals* $abcd$, $abc$ *came but* $d$ *didn't.*)

a. ✓ Most $x$ [$x$ is an $\underbrace{\text{atomic true short answer of Q}}_{\{a,b,c\}}$ ] [J knows that $x$ came]

b. ✓ Most $p$ [$p$ is an $\underbrace{\text{atomic true propositional answer of Q}}_{\{{}^\wedge \textit{came}(a),\, {}^\wedge \textit{came}(b),\, {}^\wedge \textit{came}(c)\}}$ ] [J knows $p$ ]

Atomic propositional answers are those that only entail themselves:

(7) $\textsc{At}(Q) = \{p : p \in Q \wedge \forall q \in Q[p \subseteq q \rightarrow q = p]\}$

[3] This generalization is made based on 28 languages from Indo-European, Finno-Ugric, and Semitic families. It also extends to Tlingit and Haida (Cable 2005) and Chuj (Kotek and Erlewine 2016).

- **Problem with the proposition-based account**

  But, if the predicate of the embedded question is **non-divisive**, this domain restriction cannot be recovered based propositional answers (Schwarz 1994).

(8) Jenny mostly knows [$_{\text{Q}}$ which professors formed the committee].
$\rightsquigarrow$ 'For most of the professors in the committee, Jenny knows that they were in the committee.'
($w$: *The committee was formed by three professors* $abc$.)

a. ✓ Most $x$ [ $x$ is $\underbrace{\text{an atomic subpart of the true short answer of Q}}_{\text{At}(a \oplus b \oplus c) = \{a, b, c\}}$ ] [J knows that $x$ was in the committee]

b. ✗ Most $p$ [$p$ is $\underbrace{\text{an atomic true propositional answer of Q}}_{\{\hat{}\textit{f.t.comm.}(a \oplus b \oplus c)\}}$ ] [J knows $p$]

> **Prediction:** Short answers must be derivable from the denotation of an embedded question.

- **A salvaging strategy and its problems**

  Williams (2000) salvages the proposition-based account by interpreting the embedded question with a **sub-divisive reading**, obtained based on a collective lexicon of the *wh*-determiner.

(9) Jenny knows which professors formed the committee.
$\approx$ 'Jenny knows which prof(s) $x$ is s.t. $x$ is **part of** the group of profs who formed the committee.'

a. $[\![\text{which}]\!] = \lambda A \lambda P.\{\lambda w.\exists y \in A[y \geq x \wedge P_w(y)] : x \in A\}$

b. $[\![\text{which profs}_{@}\text{ f.t.c.}]\!] = \{\lambda w.\exists y[{}^{*}\textit{prof}_{@}(y) \wedge y \geq x \wedge \textit{f.t.c.}_w(y)] : x \in {}^{*}\textit{prof}_{@}\}$
({$x$ is part of a group of profs who formed the committee: $x$ is prof(s)})

But, this sub-divisive reading is not observed in the corresponding matrix question. Compare:

(10) a. Who is part of the professors who formed the committee, for example?
b. Which professors formed the committee, # for example?

The partiality marker *for example* presupposes the existence of an incomplete true answers, and thus cannot be used in questions with only one true answer.

(11) a. Which student came, # for example?
b. Is it raining, # for example?
c. Zhiyou shei lai -le, # ju-ge lizi? *Mandarin*
only who come -PERF give-CL example
Intended: 'Which people $x$ is such that **only** $x$ came, # for example?'

The infelicity of using *for example* in (10b) suggests that *which profs formed a committee* admits only a collective reading, under which this question can have only one true answer. Conversely, if it admits a sub-distributive reading, the use of *for example* in (10b) would be felicitous, contra fact.

> **Interim Summary**
>
> Caponigro's generalization and QV effects show that the root denotation of a question must be able to supply nominal and predicative meanings. This requirement leaves $\lambda$-abstract the only possible denotation of a question. Thus, we have to pursue a categorial approach.

## 2. Traditional categorial approaches and their problems

### 2.1. Assumptions of traditional categorial approaches

- Questions denote $\lambda$-abstracts.

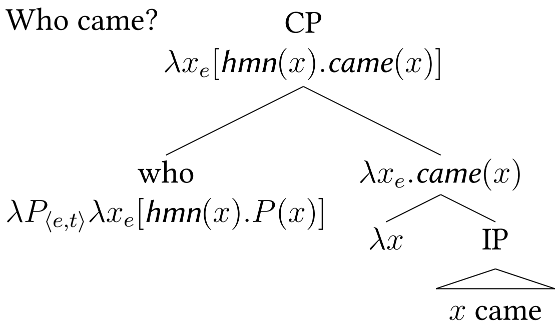
(12) a. $[\![\text{who came}]\!] = \lambda x[\mathit{hmn}(x).\mathit{came}(x)]$
b. $[\![\text{who bought what}]\!] = \lambda x \lambda y[\mathit{hmn}(x) \wedge \mathit{thing}(y).\mathit{bought}(x, y)]$

The *wh*-determiner is a $\lambda$-operator.

(13) a. $[\![\text{wh-}]\!] = \lambda A_{\langle e,t\rangle} \lambda P_{\langle e,t\rangle} \lambda x_e[A(x).P(x)]$
b. $[\![\text{who}]\!] = \lambda P_{\langle e,t\rangle} \lambda x_e[\mathit{hmn}(x).P(x)]$

- Composing a single-*wh* question:

(14) Who came?




### 2.2. Problems of traditional categorial approaches

- **Problem 1. Existential semantics of *wh*-words**
In many languages, *wh*-items are interpreted as **existential indefinites** in non-interrogatives (as seen in German, Romance, Italian, Dutch, Greek, Mandarin, Vietnamese, ...).

> "In my 100-language sample, there are 64 languages whose indefinites are based on interrogatives. Of these 64 languages, 31 languages, or almost one third of the whole sample, have bare interrogatives. It is extremely unlikely that zero-grammaticalization should happen so often, and so systematically." (Haspelmath 1997: pp. 174)

(15) Mandarin *shenme-ren* 'what-person'

a. Yuehan haoxiang jian-le **shenme-ren**.
John perhaps meet-PERF what-person
'It seems that John met **someone**.'

b. Ruguo Yuehan jian-guo **shenme-ren**, qing gaosu wo.
If John meet-EXP what-person, please tell me.
'If John met **someone**, please tell me.'

(16) Old High German *waz* 'what' and 'wer' 'who' (Behaghel 1917)

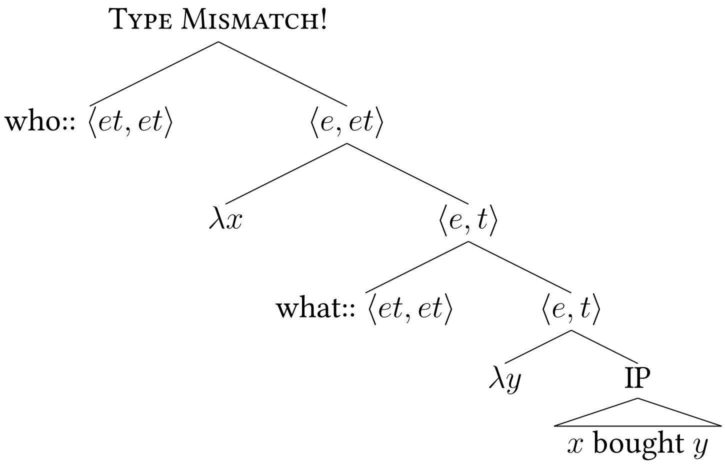
a. Ther fon imo saget **waz**, ther suachit io thaz sinaz.
who from him says what he seeks always the own
'Whoever says **something** of him, he always seeks his own (thing).'

b. Gisehet ir, thaz **wer** iuuuih ni forleite.
see you that who you not lead.astray
'Take care that **someone** does not lead you astray.'

Defining the *wh*-determiner as a $\lambda$-operator, traditional categorial approaches cannot capture the existential semantics of *wh*-items.

- **Problem 2: Composing the single-pair reading of $\mathbf{Q_{multi\text{-}\mathit{wh}}}$ suffers type mismatch.**

(17) $[\![\text{who bought what}]\!] = \lambda x \lambda y[\mathit{hmn}(x) \wedge \mathit{thing}(y).\mathit{bought}(x, y)]$




- **Problem 3: Coordinations of questions**

Conjunction and disjunction are standardly defined as **meet** $\sqcap$ and **join** $\sqcup$. Coordinated expressions must be of the same **conjoinable type**. (Partee & Rooth 1983, Groenendijk & Stokhof 1989)

(18) **Conjoinable type**

a. $t$ is a conjoinable type;

b. If $\tau$ is a conjoinable type, then for any type $\sigma$: $\langle \sigma, \tau \rangle$ is a conjoinable type.

(19) **Meet**

$$A' \sqcap B' = \begin{cases} A' \wedge B' & \text{if } A' \text{ and } B' \text{ are of type } t \\ \lambda x[A'(x) \sqcap B'(x)] & \text{if } A' \text{ and } B' \text{ are of some other conjoinable type} \\ \text{undefined} & \text{otherwise} \end{cases}$$

(20) Examples:

| | | |
|---|---|---|
| a. | jump and run | $\mathit{jump}_{\langle e,t \rangle} \sqcap \mathit{run}_{\langle e,t \rangle}$ |
| b. | * jump and look for | $\#\mathit{jump}_{\langle e,t \rangle} \sqcap \mathit{look\text{-}for}_{\langle e,et \rangle}$ |
| c. | Jenny and every student | $\textsc{Lift}(\mathit{Jenny})_{\langle et,t \rangle} \sqcap \mathit{every\ student}_{\langle et,t \rangle}$ |
| d. | * Jenny and student | $\#\textsc{Lift}(\mathit{Jenny})_{\langle et,t \rangle} \sqcap \mathit{student}_{\langle e,t \rangle}$<br>$\#\mathit{Jenny}_e \sqcap \mathit{student}_{\langle e,t \rangle}$ |

Questions can be coordinated. But categorial approaches assign them different semantic types.

(21) Jenny knows [[who came]$_{\langle e,t \rangle}$ **and**/**or** [who bought what]$_{\langle e,et \rangle}$]

Even if the coordinated questions are of the same conjoinable type, traditional categorial approaches do not predict the correct reading.[4]

(22) Jenny knows [$_{\langle e,t \rangle}$ who voted for Andy] and [$_{\langle e,t \rangle}$ who voted for Billy].
(Predicted reading: # 'Jenny knows who voted for both Andy and Billy.')

(23) $[\![\text{who voted for Andy}]\!] \sqcap [\![\text{who voted for Billy}]\!]$
$= \lambda x[\mathit{vote\text{-}for}(x, a)] \sqcap \lambda x[\mathit{vote\text{-}for}(x, b)]$
$= \lambda x[\mathit{vote\text{-}for}(x, a) \wedge \mathit{vote\text{-}for}(x, b)]$
$= [\![\text{who voted for Andy and Billy}]\!]$

[4]Hamblin-Karttunen Semantics also has this problem: if conjunction is treated standardly as meet, the conjunction of two questions would be analyzed as the intersection of two proposition sets. Inquisitive Semantics solves this problem. (Ciardelli & Roelofsen 2015, Ciardelli et al. 2017)

> **Interim summary**
> Traditional categorial approaches cannot capture the ∃-semantics of *wh*-words, suffer type-mismatch in composing multi-*wh* questions, and cannot get coordinations of questions.

## 3. Proposal: A hybrid categorial approach

For sake of simplicity, this handout ignores the technical details needed for getting mention-some readings, higher-order readings and functional readings. See appendix for extension to complex questions.

### 3.1. Question denotation

- Questions denote topical properties (i.e., $\lambda$-abstracts ranging over propositions). A topical property maps a short answer to a propositional answer.

(24) Which student came? Jenny.

a. $\mathbf{P} = \lambda x[\textit{student}_{@}(x) = 1.{}^\wedge\textit{came}(x)]$

b. $\mathbf{P}(j) = {}^\wedge\textit{came}(j)$

### 3.2. Question composition

- The domain of a topical property equals to the extension of the *wh*-complement. Defining the *wh*-phrase (*wh*P) as an ∃-quantifier (*a la* Karttunen 1977, Heim 1995), we can extract out this domain by applying a Be-shifter to *wh*P.

(25) Be converts an ∃-quantifier to its live-on set:[5]

a. $[\![\text{which student}_{@}]\!] = \lambda f_{\langle e,t\rangle}.\exists x \in \textit{student}_{@}[f(x)]$

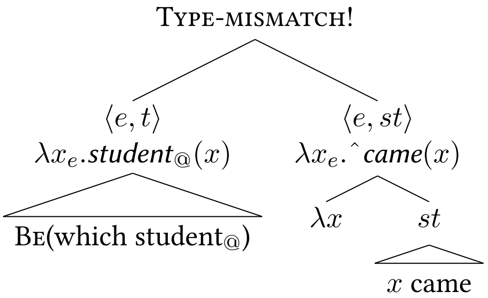
b. $\textsc{Be} = \lambda \mathcal{P}_{\langle \tau t,t\rangle}\lambda z_\tau[\mathcal{P}(\lambda y.y = z)]$ (Partee 1986)

c. $\textsc{Be}([\![\text{which student}_{@}]\!]) = \textit{student}_{@}$

- *A technical difficulty:* How can we incorporate $\textsc{Be}(wh\text{P})$ into the topical property?

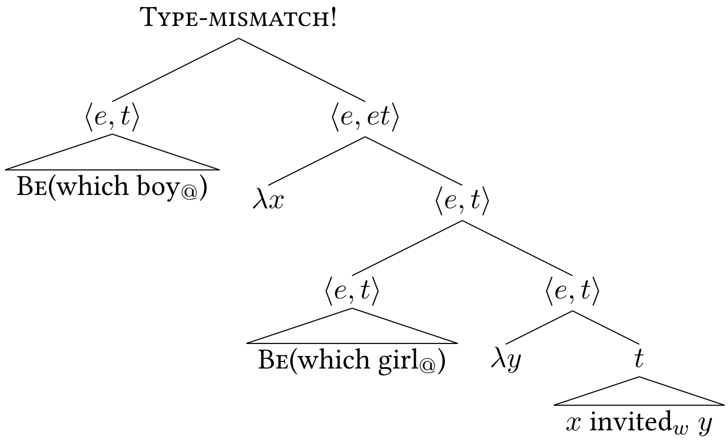
  Note that Predicate Modification doesn't work:

(26) Which student came?




(*Extension-intension mismatch*)

(27) Which boy invited which girl?



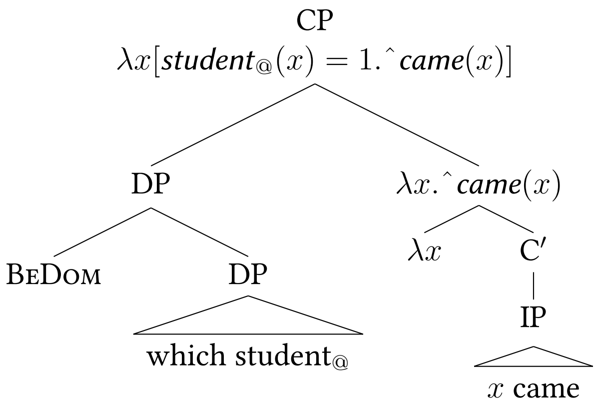

(*Composing Multi-wh*)

[5] Live-on sets: A generalized quantifier $\mathcal{P}$ lives on a set $A$ iff for any set $B$: $B \in \mathcal{P} \Leftrightarrow B \cap A \in \mathcal{P}$. (Barwise & Cooper 1981)

*Solution*: A **BeDom-operator** converts the *wh*P into a **domain restrictor**. Moving BeDom(*wh*P) to [Spec, CP] yields a partial property that is only defined for individuals in Be(*wh*P).

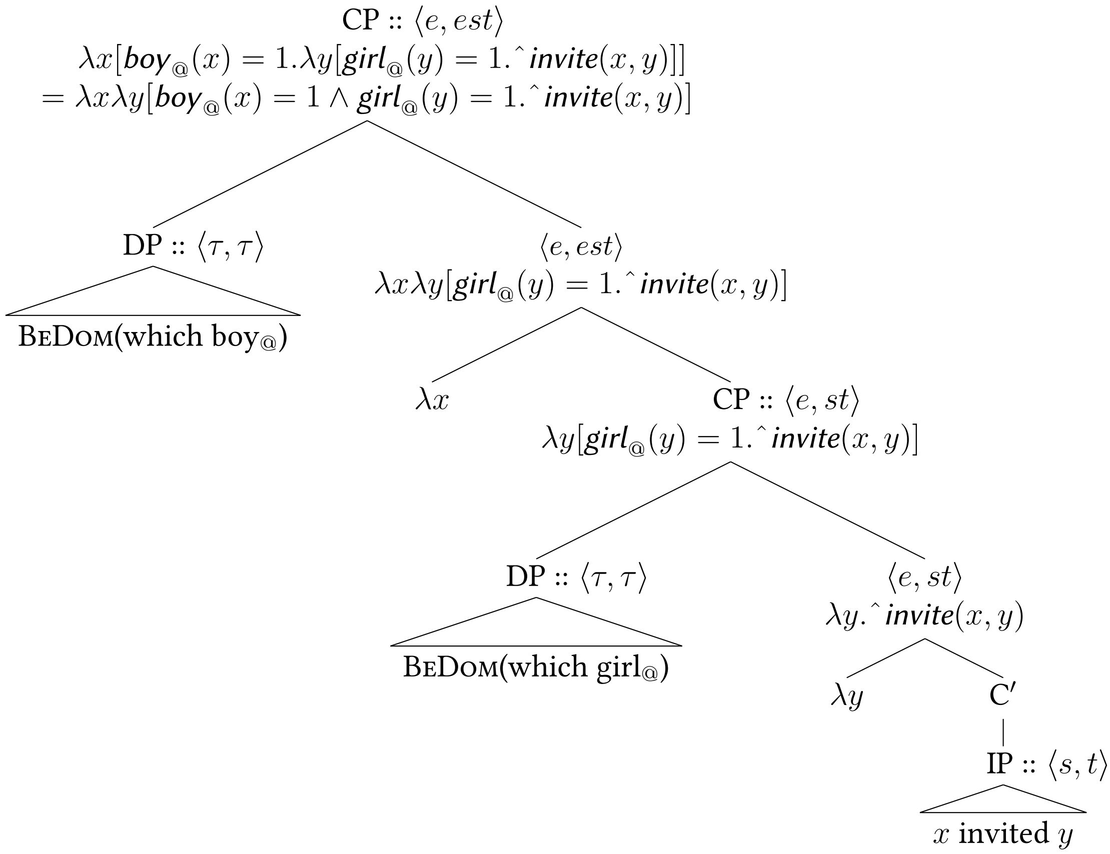
(28) $\textsc{BeDom}(\mathcal{P}) = \lambda\theta_\tau.\iota P_\tau[[\mathrm{Dom}(P) = \mathrm{Dom}(\theta) \cap \textsc{Be}(\mathcal{P})] \wedge \forall\alpha \in \mathrm{Dom}(P)[P(\alpha) = \theta(\alpha)]]$
(For any function $\theta$, restrict the domain of $\theta$ with $\textsc{Be}(\mathcal{P})$.)

(29) Which student came?




- $\textsc{BeDom}(\mathcal{P})$ is polymorphic (of type $\langle\tau,\tau\rangle$). Hence, composing multi-*wh* doesn't suffer type-mismatch.

(30) Which boy invited which girl? (Single-pair reading)




### 3.3. Deriving answers

- Short answers and propositional answers:

| Dom($\mathbf{P}$) | *student*$_@$ |
|---|---|
| $\{\mathbf{P}(\alpha) : \alpha \in \mathrm{Dom}(\mathbf{P})\}$ | $\{{}^\wedge\textit{came}(x) : x \in \textit{student}_@\}$ |

- Dayal (1996): The complete true answer of a question is the strongest true proposition in the Hamblin set of this question, namely, the unique true answer that entails all the true answers.

(31) $\textsc{Ans}_{\text{Dayal}}(Q)(w) = \iota p[w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow p \subseteq q]]$ (presupposition ignored)

Adapting to the proposed hybrid categorial approach:

(32) For the complete true **short** answer:
$\textsc{Ans}^{\text{S}}(\mathbf{P})(w) = \iota\alpha[\alpha \in \text{Dom}(\mathbf{P}) \wedge w \in \mathbf{P}(\alpha) \wedge \forall\beta \in \text{Dom}(\mathbf{P})[w \in \mathbf{P}(\beta) \rightarrow \mathbf{P}(\alpha) \subseteq \mathbf{P}(\beta)]]$

(33) For the complete true **propositional** answer:
$\textsc{Ans}(\mathbf{P})(w) = \mathbf{P}(\textsc{Ans}^{\text{S}}(\mathbf{P})(w))$

**Interim Summary**

- The root denotation of a question is a topical property. In deriving this topical property, a BeDom-operator converts a *wh*-item into a type-flexible domain restrictor.
- An answerhood-operator Ans/Ans$^S$ directly operates on the topical property, returning the complete true propositional/short answer.

## 4. Getting coordinations of questions

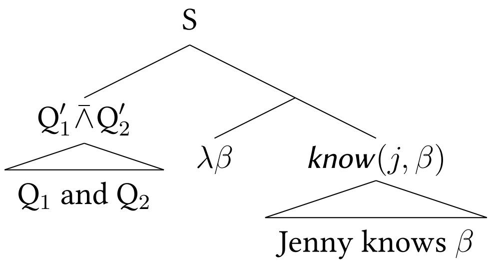
- **Solution**: Coordinations can be interpreted either as meet/join or generalized quantifiers (GQs). The domain restriction of a GQ can be polymorphic (i.e., containing elements of different types).[6]

(34) a. **Generalized conjunction**
$A' \bar{\wedge} B' = \lambda\alpha[\alpha(A') \wedge \alpha(B')]$
$= \lambda\alpha.\{A', B'\} \subseteq \alpha$

b. **Generalized disjunction**
$A' \bar{\vee} B' = \lambda\alpha[\alpha(A') \vee \alpha(B')]$
$= \lambda\alpha[\{A', B'\} \cap \alpha \neq \varnothing]$

Question coordinations are GQs. When embedded, a question coordination undertakes QR and moves to the left edge of the matrix clause.[7]

(35) Jenny knows [[$_{\text{Q}_1}$ who came] and [$_{\text{Q}_2}$ who bought what]].




$$
\begin{aligned}
[\![\text{S}]\!] &= (\text{Q}'_1 \bar{\wedge} \text{Q}'_2)(\lambda\beta.\textit{know}(j,\beta)) \\
&= (\lambda\alpha.[\alpha(\text{Q}'_1) \wedge \alpha(\text{Q}'_2)])(\lambda\beta.\textit{know}(j,\beta)) \\
&= (\lambda\beta.\textit{know}(j,\beta))(\text{Q}'_1) \wedge (\lambda\beta.\textit{know}(j,\beta))(\text{Q}'_2) \\
&= \textit{know}(j, \text{Q}'_1) \wedge \textit{know}(j, \text{Q}'_2) \\
&= \textit{know}(j, \lambda x.\hat{}\,\textit{came}(x)) \wedge \textit{know}(j, \lambda x\lambda y.\hat{}\,\textit{bought}(x,y))
\end{aligned}
$$

(Jenny knows who came, and she knows who bought what.)

**Prediction:** A question coordination has to scope over an embedding predicate.

This prediction cannot be evaluated based on (35) because *know* is divisive:
$$\textit{know}(j, p \sqcap q) \Leftrightarrow \textit{know}(j,p) \sqcap \textit{know}(j,q)$$

[6] This definition of generalized conjunction/disjunction is different from the one given by Partee & Rooth (1983). P&R treat conjunction as meet over Montague-lifted conjuncts: $[\![A \text{ and } B]\!] = \textsc{Lift}(A') \sqcap \textsc{Lift}(B') = (\lambda P.P(A')) \sqcap (\lambda P.P(B'))$. Unlike the proposed definition, P&R's requires $\textsc{Lift}(A')$ and $\textsc{Lift}(B')$ to be of the same conjoinable type.

[7] Upon finishing this handout, I noticed that this analysis has been discussed briefly by Krifka (2011: pp. 1757). There is still however a technical problem with this approach: the sister node of the question coordination cannot have a fixed semantic type (Danny Fox and Floris Roelofsen p.c. independently).

– *Evidence 1*: [$\text{Q}_1$ and $\text{Q}_2$] $>$ *surprise*
Conjunctions of questions under **non-divisive** predicates admit only wide scope readings.

(36) a. John is **surprised** that [Mary went to Boston] and [Sue went to Chicago]. (He expected them go to the same city.)
$\not\rightsquigarrow$ John is surprised that Mary went to Boston.
b. John is **surprised** at [who went to Boston] and [who went to Chicago].
$\rightsquigarrow$ John is surprised at who went to Boston.

– *Evidence 2*: [$\text{Q}_1$ or $\text{Q}_2$] $>$ *know*
In (37b), John needs to know the complete true answer of one of the questions, not just the disjunction of the complete true answers of the two questions.

| *Mary invite ...* | $a$ | $b$ | $a$ *or* $b$ (*or both*) |
|---|---|---|---|
| Fact | Yes | Yes | Yes |
| John's belief | ? | ? | Yes |

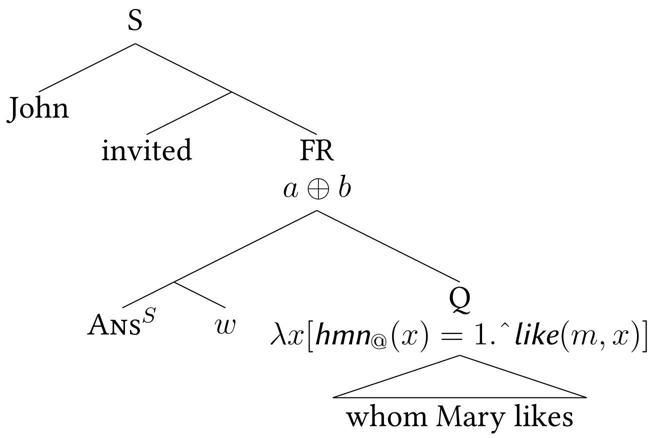
(37) a. John knows that Mary invited $a$ or $b$ (or both). TRUE
b. John knows [whether Mary invited $a$] **or** [whether Mary invited $b$]. FALSE

## 5. Applications

### 5.1. Free relatives

- *Wh*-FRs are derived from *wh*-questions with the application of an $\text{ANS}^S$-determiner.[8]

(38) John invited [$_{\text{FR}}$ whom Mary likes]. ($w$: *Mary only likes Andy and Billy.*)




☞ Caponigro's generalization is captured as long as the application of $\text{ANS}^S$ can sometimes be blocked.

### 5.2. Getting quantificational variability effects

- The quantification domain of the quantity adverbial can be recovered based on the complete true short answer of the embedded question:

(39) QV inference of "Jenny mostly knows Q":
$\lambda w.\text{MOST}\ x[x \in \text{AT}(\text{ANS}^S([\![\text{Q}]\!])(w))]\ [\textit{know}_w(j, \lambda w'.x \leq \text{ANS}^S([\![\text{Q}]\!])(w'))]$
($\lambda w$. MOST $x$ [ $x$ is an atomic subpart of the complete true short answer of Q in $w$ ] [Jenny knows that $x$ is a part of the complete true short answer of Q])

[8]The analysis presented here is essentially the same as Jacobson (1995), since this handout ignores details on existential readings of FRs (as in *John went to where he can get help*). See Xiang (2016: ch. 1) for how to get such readings.

(40) For the most part, Jenny knows [$_{\mathrm{Q}}$ which professors formed the committee].
($w$: *The committee is formed by three professors* $abc$.)

a. $\textsc{Ans}^S([\![\mathrm{Q}]\!])(w) = \{a \oplus b \oplus c\}$

b. $\textsc{At}(a \oplus b \oplus c) = \{a, b, c\}$

c. QV inference: $\lambda w.\textsc{Most}\ x[x \in \{a,b,c\}]\ [\textit{know}_w(j, \lambda w'.x \leq \textsc{Ans}^S([\![\mathrm{Q}]\!])(w'))]$
($\textsc{Most}\ x[x \in \{a,b,c\}]$ [J knows that $x$ is part of the people who formed the committee])

**Conclusions**

- **Reasons for pursing a categorial approach:**
  - Caponigro's generalization
  - Quantificational variability effects
- **Problems with traditional categorial approaches**
  - Existential semantics of *wh*-words
  - Type-mismatch in composing multi-*wh* questions
  - Coordinations of questions
- **A hybrid categorial approach**
  - *Wh*-phrases are existential quantifiers.
  - The root denotation of a question is a topical property.
  - In composition, BeDom shifts the *wh*-phrase into a type-flexible domain restrictor.
- **Question coordinations** are generalized quantifiers. The conjunctive/disjunctive coordinates two predications (of type $t$), not directly the root denotations of the involved questions.
- **Applications:** Free relatives, QV effects

## Appendix I: Comparing canonical approaches to question semantics

| | Categorial | Karttunen | Hamblin | Partition |
|---|---|---|---|---|
| Nominal short answers | ✓ | ✗ | ✗ | (✓) |
| *Wh*-items as $\exists$-indefinites | ✗ | ✓ | ✗ | ✗ |
| Composing multi-*wh* | ✗ | ✓ | ✓ | ✓ |
| Conjunctions of questions | ✗ | ✓ | ✓ | ✓ |

## Appendix II: Deriving answers from single-pair reading multi-*wh* questions

- The denotation of a single-pair reading multi-*wh*-question is not a function from short answers to propositional answers. Deriving answers can make use of **tuple types** (George 2011: Appendix A):

  (i) An *n*-ary sequence $(x_1; x_2; ...; x_n)$ takes a tuple type $(\tau_1; \tau_2; ...; \tau_n)$,

  (ii) $\langle \tau_1 \langle \tau_2 \langle ... \langle \tau_n, \sigma \rangle, ... \rangle$ equals to $\langle (\tau_1; \tau_2; ...; \tau_n), \sigma \rangle$

  Example:

(41) Which boy invited which girl? (Single-pair reading)
($w$: *John invited only Mary; no other boy invited any girl.*)

a. $\mathbf{P} = \lambda x \lambda y[\textit{boy}_@(x) = 1 \wedge \textit{girl}_@(y) = 1.\,^\wedge\textit{invite}(x, y)]$

b. $\mathrm{Dom}(\mathbf{P}) = \{(x; y) : x \in \textit{boy}_@, y \in \textit{girl}_@\}$

c. $\{\mathbf{P}(\alpha) : \alpha \in \mathrm{Dom}(\mathbf{P})\} = \{^\wedge\textit{invite}(x, y) : x \in \textit{boy}_@, y \in \textit{girl}_@\}$

## Appendix III: Composing complex questions (Xiang 2016: ch. 5-6, 2017)

- Pair-list readings of $\text{Q}_{\text{multi-}wh}$ and $\text{Q}_{\forall}$ are not semantically equivalent and must be treated differently. Only that of $\text{Q}_{\forall}$ is subject to domain exhaustivity (contra Dayal 2002, Fox 2012a):

(42) (Context: *100 candidates are competing for 3 jobs.*)
$\surd$ "Guess which candidate will get which job."
\# "Guess which job will every candidate get."

(43) (Context: *4 kids are playing Musical Chairs and are competing for 3 chairs.*)
"Guess which of the 4 kids will sit on which of the 3 chairs."
$\not\rightsquigarrow$ Each of the 4 kids will sit on one of the 3 chairs.

- Pair-list readings of $\text{Q}_{\forall}$ and choice readings of $\text{Q}_{\exists}$ are both subject to subject-object/adjunct asymmetry (Chierchia 1991, 1993):

(44) a. Which candidate did **every student**$_{\text{subj}}$ vote for? — $\surd$ pair-list
b. Which student voted for **every candidate**$_{\text{obj}}$? — $\times$ pair-list

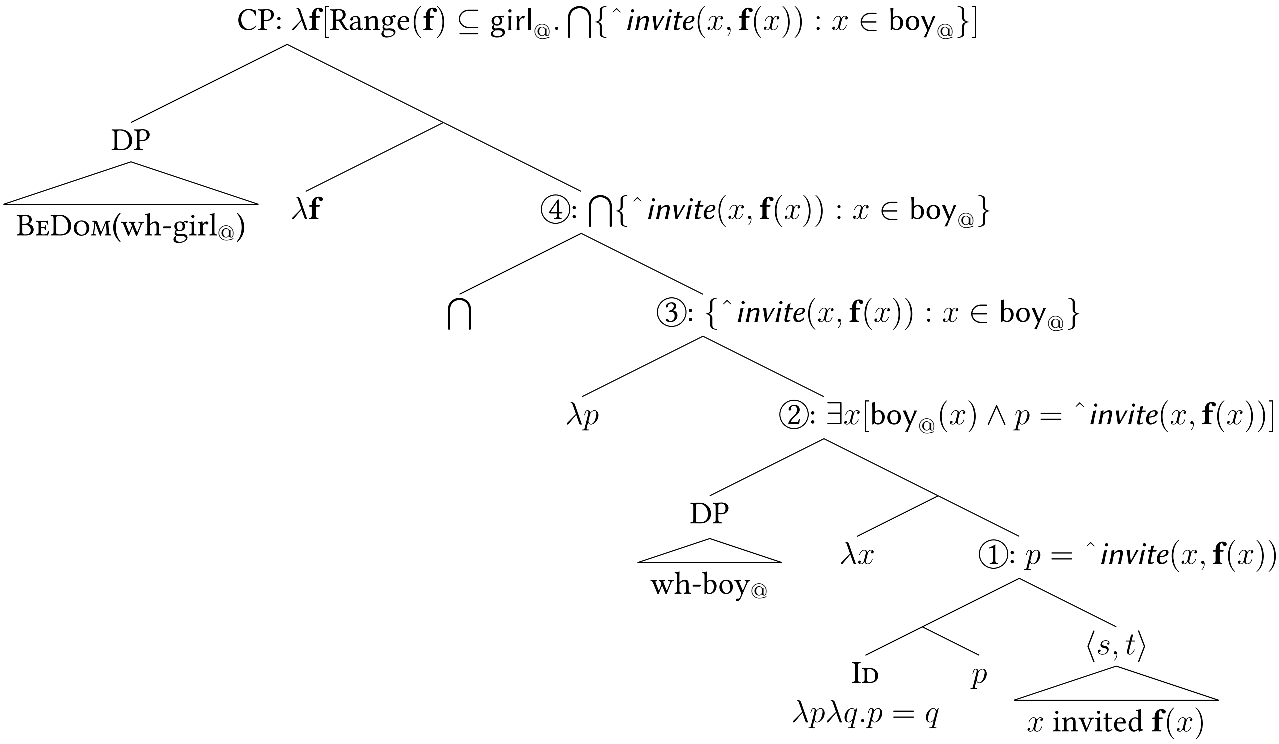
(45) a. Which candidate did **one of the students**$_{\text{subj}}$ vote for? — $\surd$ choice
b. Which student voted for **one of the candidates**$_{\text{obj}}$? — ?choice

☞ We shall unify the treatment of quantifying-into question readings, not the pair-list readings.

- I treat the aforementioned list and choice readings as **special functional readings**: the object-*wh* trace is functional, and its argument variable is bound by the *wh*-/∀-/∃-subject. (Cf. Engdahl 1980, 1986; Groenendijk and Stokhof 1984; Chierchia 1993; Dayal 1996, 2016, 2017)

- **Part A. Composing pair-list readings of multi-*wh* questions**

(46) Which boy invited which girl?

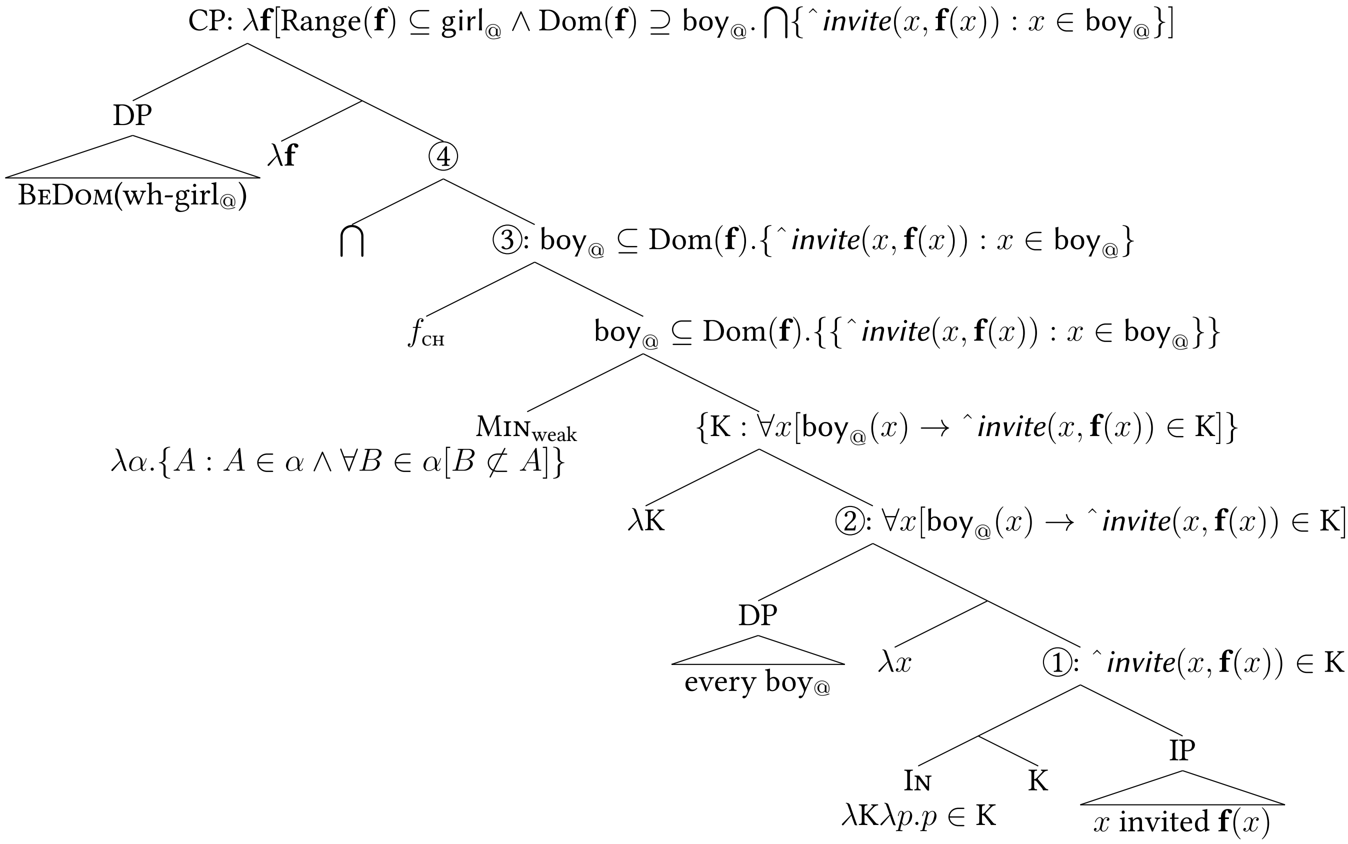



Functions that are possible short answers of this question do not have to be defined for all the boys. Hence no domain exhaustivity.

- **Part B. Composing pair-list readings of ∀-questions**

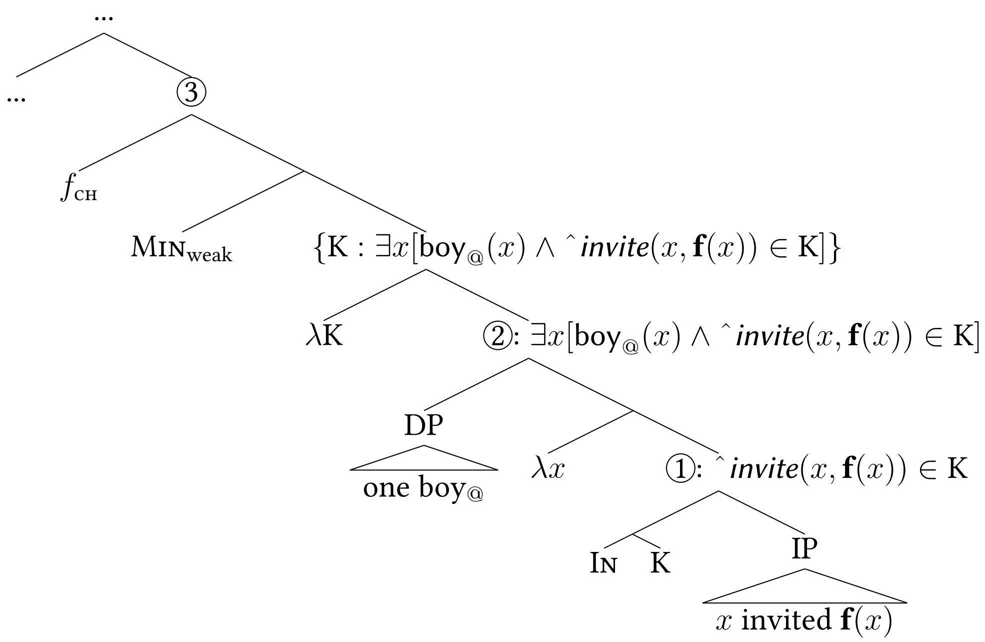
  Two tricks: (i) letting the quantifier quantifies into a membership relation, (ii) extracting out a minimal K set that satisfies the quantified membership relation.[9] Crucially, the meaning of Node ② presupposes that **f** is defined for every boy. This presupposition projects and yields domain exhaustivity.

(47) Which girl did every boy invite?




- **Part C. Composing choice readings of $Q_\exists$** (the same as composing the pair-list reading of $Q_\forall$)

(48) Which girl did one of the boys invite?




[9] These tricks have been reached by Fox (2012b). My analysis overcomes the following problems: (i) Fox pursues a family-of-question approach for both $Q_{\text{multi-}wh}$ and $Q_\forall$, which cannot explain the semantic differences between their pair-list readings; (ii) Fox uses Pafel's (1999) Min-operator ($[\![\text{Min}]\!]_{\text{Pafel-Fox}} = \lambda\alpha.\iota A[A \in \alpha \wedge \forall B \in \alpha[A \subseteq B]]$), which cannot extend to $Q_\exists$.

**Compare the derivations of the two pair-list readings:**

- In $\text{Q}_{\text{multi-wh}}$, *which boy* existentially quantifies into an **identity** relation;
  In $\text{Q}_{\forall}$, *every boy* universally quantifies into a **membership** relation.
- At node ③, both derivations return the proposition set $\{{}^\wedge \textit{invite}(x, \mathbf{f}(x)) : x \in \text{boy}_{@}\}$. But the one in $\text{Q}_{\forall}$ also presupposes that $\mathbf{f}$ is defined for every boy, yielding domain exhaustivity.

**Compare $\text{Q}_{\forall}$ and $\text{Q}_{\exists}$:**

- $\text{Q}_{\forall}$ doesn't take a choice reading: there is **only one** minimal eligible K set that contains all propositions of the form 'boy $x$ invited $\mathbf{f}(x)$'.

  $\text{Q}_{\exists}$ takes a choice reading: there are **multiple** minimal sets that contain one proposition of the form 'boy $x$ invited $\mathbf{f}(x)$'. Each minimal set yields a possible Q.
- $\text{Q}_{\forall}$ takes a pair-list reading: the unique eligible minimal set is **non-singleton**.

  $\text{Q}_{\exists}$ doesn't take a pair-list reading: all the eligible minimal sets are **singletons**.

- **Part D. Accounting for the QV effects**

(49) John mostly knows [$_{\text{Q}_{\text{multi-wh}}}$ which boy invited which girl].
... [$_{\text{Q}_{\forall}}$ which girl every boy invited].
$\rightsquigarrow$ Most $p$ [$p$ is a true atomic proposition 'boy $x$ invited girl $y$'] [John knows $p$]

The domain of *mostly* is defined based on the atomic parts of functions.

(50) Atomic functions and atomic parts of functions
a. A function $\mathbf{f}$ is atomic iff $\bigoplus \text{Dom}(\text{f}')$ is atomic.
b. $\textsc{At}(\mathbf{f}) = \{\text{f}' : \text{f}' \subseteq \mathbf{f} \text{ and } \bigoplus \text{Dom}(\text{f}') \text{ is atomic}\}$

(51) QV inferences of $\text{Q}_{\text{multi-wh}}$ and $\text{Q}_{\forall}$
a. $\lambda w.\textsc{Most}\ \text{f}'[\text{f}' \in \textsc{At}(\textsc{Ans}^S([\![\text{Q}_{\text{multi-wh}}]\!])(w))][\textit{knows}_w(j, [\![\text{Q}_{\text{multi-wh}}]\!](\text{f}'))]$
b. $\lambda w.\textsc{Most}\ \text{f}'[\text{f}' \in \textsc{At}(\textsc{Ans}^S([\![\text{Q}_{\forall}]\!])(w))][\textit{know}_w(j, \lambda w'.\text{f}' \leq \textsc{Ans}^S([\![\text{Q}_{\forall}]\!])(w'))]$

Example:

(52) John mostly knows [which boy invited which girl].
($w$: $abc$ *invited only* $jms$, *respectively; no other boy invited any of the girls.*)
a. $\textsc{Ans}^S([\![\text{Q}_{\text{multi-wh}}]\!])(w) = \left\{ \begin{array}{c} a \to m \\ b \to j \\ c \to s \end{array} \right\}$
b. The QV inference:

$$\lambda w.\textsc{Most}\ \text{f}'\left[\text{f}' \in \left\{ \begin{array}{c} \{a \to m\} \\ \{b \to j\} \\ \{c \to s\} \end{array} \right\}\right]\left[\textsf{know}_w(j, \bigcap\{{}^\wedge\textsf{invite}(x, \text{f}'(x)) : x \in \textsf{boy}_{@}\})\right]$$

$$= \lambda w.\textsc{Most}\ \text{f}'\left[\text{f}' \in \left\{ \begin{array}{c} \{a \to m\} \\ \{b \to j\} \\ \{c \to s\} \end{array} \right\}\right]\left[\textsf{know}_w(j, {}^\wedge\textsf{invite}(x, \text{f}'(x)))\right]$$

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