

Tutorial: Quantifying into questions

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1. Introduction

- Interpretations of questions with quantifiers:

- (1) Which book did **every student** read? (Engdahl 1980)
- a. *Individual reading* ($t \gg \forall$)
'Which book y is s.t. every student read y ?' 'Minimalist Program.'
 - b. *Functional reading* ($t \gg \forall$)
'Which function f to a book is s.t. every student x read $f(x)$?' 'His favorite book.'
 - c. *Pair-list reading* ($\forall \gg t$)
'For every student x , which book did x read?'
'Andy read *Minimalist Program*, Billy read *Sentence Structure*.'
- (2) Which book did **one of the students** read?¹
- a. *Individual reading* ($t \gg \exists$)
'Which book y is s.t. one of the students student read y ?' 'Minimalist Program.'
 - b. *Choice reading* ($\exists \gg t$)
'For one of the students x , which book did x read?'
'Andy read *Minimalist Program*.' / 'Billy read *Sentence Structure*.'

Pair-list/choice readings of \forall/\exists -questions intuitively involve "quantification into questions (QiQ)," henceforth called **QiQ readings**.

- It is difficult to derive QiQ readings compositionally.
- The LF (3) is ill-formed in Hamblin-Karttunen Semantics: the argument of *every student* shall be of type $\langle e, t \rangle$ (namely, quantifiers shall quantify into truth values), not $\langle e, stt \rangle$.

(3) * [[every student] λx [Q which book did x read]]

- It's appealing to assume that the quantifier scopes over a covert Q-embedding predicate *ask*/QUEST.

- (4) Which book did every students read?
- a. *For every student x , I ask you which book did x read.* (Karttunen 1977)
 - b. [[every student] _{$\langle ea, a \rangle$} λy [QUEST _{$\langle stt, a \rangle$} [which book did x read]]] (Krifka 2001)

But, the quantification in QiQ is "internal". In embeddings, the quantifier of the embedded question cannot scope over a quantifier in the matrix clause. (Moltmann & Szabolcsi 1994, Fox 2000)

- (5) **A waiter** knows which wine **every customer** ordered.
 $\not\approx$ *For every customer x , there is a waiter who know which wine x ordered.* ($\times \forall \gg \exists$)

¹Functional readings are unavailable in \exists -questions: (2) can't be answered by 'his favorite book.'

– No quantification at all? Engdahl (1980): QiQ readings are extensional functional readings.

- (6) Which function $f_{\langle e,e \rangle}$ is such that every student x read $f(x)$?
- Every man ate what his wife recommended.
 - Bill ate the chocolate cake, Tom the rice pudding, and Fred the raspberry pie.

But, QiQ readings and ordinary inverse scope readings are constrained in similar ways; for instance, \forall -quantifiers cannot scope out of declarative finite clauses. (Pafel 1999)

- (7) a. A candidate believes that every student voted for him. [\times inverse scope]
b. Which candidate does Susan believe that every student voted for? [\times pair-list]

2. Properties of QiQ readings

• **Subject-object/adjunct asymmetry:** QiQ readings are available only when the non-*wh* quantifier serves as the subject and the *wh*-item as an object/adjunct. (Chierchia 1991, 1993)

- (8) a. Which candidate did [every student] vote for? \checkmark pair-list
b. Which student voted for [every candidate]? \times pair-list
- (9) a. Which candidate did [one of the students] vote for? \checkmark choice
b. Which person voted for [one of the students]? ??choice

Prediction I: The similarity in syntax suggests that QiQ readings shall have similar LFs.

• **Domain exhaustivity**

– Pair-list readings of \forall -questions presuppose domain exhaustivity: every element in the domain of the \forall -subject is paired with an element in the domain of the *wh*-object. (Dayal 2002)

- (10) Which book did every student read?
 \rightsquigarrow *Every student read a book.*

– But, pair-list readings of multi-*wh* questions are NOT subject to domain exhaustivity. (Xiang 2016; contra Dayal 2002, Fox 2012a)

- (11) (Context: 100 candidates are competing for 3 job openings.)
a. Guess which candidate will get which job.
b. # Guess which job will every/each candidate get.
- (12) (Context: 4 kids are playing the game of musical chairs and are competing for 3 chairs.)
a. Guess which kid will sit on which chair.
b. # Guess which chair each/every kid sit on.

Prediction II: The contrast wrt domain exhaustivity suggests that pair-list readings of \forall -questions and multi-*wh* questions are semantically inequivalent and must be derived via different LFs.

- **Distributing pair-list:** only \forall -questions admit pair-list readings.
- Questions with a downward monotone quantifier (Chierchia 1993):
 - (13) a. ‘Who did at most two of the students vote for?’
‘Andy voted for Mary, Billy voted for Jenny.’
 - b. ‘Who did no student vote for?’
[silence]
- The seeming pair-list answer in (14) is actually an individual answer with a cumulative reading.
 - (14) ‘Who did two of the students vote for?’
‘A and B voted for M and J. In particular, A voted for M, and B voted for J.’

Using a singular *wh*-item removes the confound:

- (15) I know that every student voted for a different candidate, please tell me ...
 - a. Which candidate did every/each student vote for? (\forall /EACH \gg ι)
 - b. # Which candidate did two of the students vote for? (\exists 2 \gg EACH \gg ι)
 - c. # Which candidate did most of the students vote for? (MOST \gg EACH \gg ι)

Previous analyses either overly predict pair-list (as in Gr&S 1984b, Chierchia 1993), or they rule out such pair-list readings by stipulating machineries that crash in non- \forall -questions (as in Gr&S 1984a, Dayal 1996, Pafel 1999, Krifka 2001, Fox 2012b), which comes at the expense of not getting choice readings of \exists -questions.

- **Quantificational variability effects** (Berman 1991): in embeddings with a quantificational adverbial (e.g., *mostly*, *for the most part*), \forall /multi-*wh* questions with pair-list readings are subject to QV effects:
 - (16) a. Jenny mostly knows who came.
 \rightsquigarrow Most x [x came] [Jenny knows that x came]
 - b. Jenny mostly knows which paper every/each student presented. (\forall -question)
 \rightsquigarrow Most x [x is a student] [Jenny knows which paper x read]
 - c. Jenny mostly knows which student read which paper. (multi-*wh* question)
 \rightsquigarrow Most x [x is a student \wedge x read a paper] [Jenny knows which paper x read]

- Theories reviewed and to be reviewed (classified based on the treatment of quantification):

- No quantifying-in (Engdahl)
- Quantifying into speech acts (Karttunen, Krifka)
- Quantifying into partitions (Gr&S-a)
- Quantifying over minimal witness sets (Gr&S-b, Chierchia, Dayal)
- Quantifying into predication (Fox)

Analyses not covered in this talk: Szabolcsi (1997), Beghelli (1997), Pafel (1999), Preuss (2001), Nicole (2013), Xiang (2016, 2018), Ciardelli & Roelofsen (2018), and more ...

3. Quantification into partition (Groenendijk & Stokhof 1984a)

- A question denotes a partition of possible worlds (of type $\langle s, st \rangle$). Given an evaluation worlds w , a world w' is in the same partition cell as w iff this question has the same true answers in w and w' .

(17) Who came?

$$\lambda w \lambda w' [(\lambda x. \text{came}_w(x)) = (\lambda x. \text{came}_{w'}(x))]$$

With only two relevant individuals John and Mary, this partition can be represented as:

$w: \text{came}_w = \{j, m, j \oplus m\}$	=	$w: \text{only } j \text{ and } m \text{ came in } w$
$w: \text{came}_w = \{j\}$		$w: \text{only } j \text{ came in } w$
$w: \text{came}_w = \{m\}$		$w: \text{only } m \text{ came in } w$
$w: \text{came}_w = \emptyset$		$w: \text{nobody came in } w$

- The \forall -question (18) denotes a partition that specifies the student-read-book pair for every student.

(18) Which book did every student read?

$$\lambda w \lambda w'. \forall x [\text{student}_w(x) \rightarrow [(\lambda y [\text{book}_w(y). \text{read}_w(x, y)]) = (\lambda y [\text{book}_{w'}(y). \text{read}_{w'}(x, y)])]]$$

($\lambda w \lambda w'$: for **every student** x is s.t. x read the same book in w and in w' .)

With only two relevant students $s_1 s_2$ and two books $b_1 b_2$, this partition can be represented as:

$w: \text{read}_w = [s_1 \rightarrow b_1, s_2 \rightarrow b_1]$
$w: \text{read}_w = [s_1 \rightarrow b_2, s_2 \rightarrow b_2]$
$w: \text{read}_w = [s_1 \rightarrow b_1, s_2 \rightarrow b_2]$
$w: \text{read}_w = [s_1 \rightarrow b_2, s_2 \rightarrow b_1]$

• Problems:

- (i) It uses a special quantifying-in rule to allow quantifying into partitions. (details omitted)
- (ii) this approach cannot extend to \exists -questions.

(19) Which book did one of the students read?

$$\lambda w \lambda w'. \exists x [\text{student}_w(x) \wedge [(\lambda y [\text{book}_w(y). \text{read}_w(x, y)]) = (\lambda y [\text{book}_{w'}(y). \text{read}_{w'}(x, y)])]]$$

($\lambda w \lambda w'$: for **one student** x is s.t. x read the same book in w and in w' .)

Consider four worlds $w_1: [s_1 \rightarrow b_1, s_2 \rightarrow b_1]$
 $w_2: [s_1 \rightarrow b_2, s_2 \rightarrow b_2]$
 $w_3: [s_1 \rightarrow b_1, s_2 \rightarrow b_2]$
 $w_4: [s_1 \rightarrow b_2, s_2 \rightarrow b_1]$, then (19) denotes the following function:

$$f = \begin{bmatrix} w_1 & \rightarrow & \{w_1, w_3, w_4\} \\ w_2 & \rightarrow & \{w_2, w_3, w_4\} \\ w_3 & \rightarrow & \{w_1, w_2, w_3\} \\ w_4 & \rightarrow & \{w_1, w_2, w_4\} \end{bmatrix}$$

- f isn't a partition; the 'cells' are overlapped (Krifka 2001).
- There is no student x s.t. we can identify which book x read. For example, with the evaluation world w_1 , since $f(w_1) = \{w_1, w_3, w_4\}$, we can't tell whether s_1 read b_1 (as in w_1 and w_3) or he read b_2 (as in w_4), nor tell whether s_2 read b_1 or b_2 .

4. Quantifying over minimal witness sets

4.1. Groenendijk & Stokhof (1984b)

- The QiQ reading involves quantification over a **minimal witness set (MWS)** of the quantifier.²

(20) \llbracket Which book did \mathcal{P} read? $\rrbracket_{\text{QiQ}} = \llbracket$ which member of A read which book \rrbracket where $\text{MWS}(\mathcal{P}, A)$

For example, let $\text{student} = \{a, b, c\}$, then:

\mathcal{P}	MWSs of \mathcal{P}	Predicted QiQ reading of ‘which book did \mathcal{P} read?’
every student	$\{a, b, c\}$	[+exh, +pair-list, –choice] ✓
one of the students	$\{a\}, \{b\}, \{c\}$	[–exh, –pair-list, +choice] ✓
two of the students	$\{a, b\}, \{b, c\}, \{a, c\}$	[–exh, +pair-list, +choice] ✗
no student	\emptyset	Unavailable ✓
at most two students	\emptyset	Unavailable ✓

- Advantages:** This account explains ...

(i) the domain exhaustivity of \forall -questions:
the MWS of a \forall -quantifier is exhaustive. (Cf., MWSs of \exists -quantifiers are not exhaustive)

(21) Which book did every student read?
= \llbracket which member in A read which book \rrbracket where $A = \{a, b, c\}$

(ii) choice readings of \exists -questions:
an \exists -quantifier has multiple MWSs, each of which provides a choice.

(22) Which book did one of the students read?
= \llbracket which member in A read which book \rrbracket where $A \in \{\{a\}, \{b\}, \{c\}\}$

(iii) the unavailability of QiQ readings in questions with a downward monotone quantifier:
the MWS of a downward monotone quantifiers is \emptyset .

(23) Which book did no student read?
= \llbracket which member in A read which book \rrbracket where $A = \emptyset$

Problem: The predicted QiQ reading is pair-list as long as the MWSs of \mathcal{P} are non-singleton. Thus this account overly predicts pair-list readings for non- \forall -questions like (24).

(24) Which book did two of the students read?
= \llbracket which member in A read which book \rrbracket where $A \in \{\{a, b\}, \{b, c\}, \{a, c\}\}$

- Andy and Billy read *Minimalist Program*.
- # Andy read *Minimalist Program*, Billy read *Sentence Structure*.

²Live-on sets and minimal witness sets (Barwise & Cooper 1981): (i) A generalized quantifier \mathcal{P} lives on a set B iff for any set C , $C \in \mathcal{P} \Leftrightarrow C \cap B \in \mathcal{P}$. (ii) If \mathcal{P} lives on a set B , A is a minimal witness set of \mathcal{P} iff $A \subseteq B$, $A \in \mathcal{P}$, and $\neg \exists A' \subset A [A' \in \mathcal{P}]$.

4.2. Chierchia (1993)

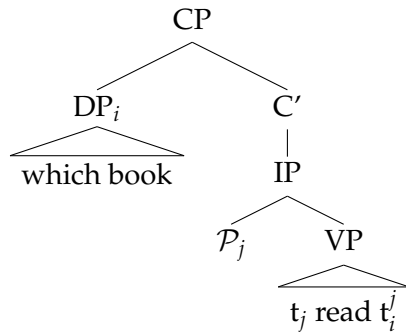
- **Motivation:** Both QiQ and functional readings are subject to subject-object asymmetry.³

- (25) a. Which book did **every student** read? (✓ Individual, ✓ Functional, ✓ Pair-list)
 b. Which student read **every book**? (✓ Individual, × Functional, × Pair-list)
 i. # Its owner (read every book).
 ii. # Andy read B1, Billy read B2.

- **Proposal:** QiQ readings are special functional readings (inspired by Engdahl 1980).

(26) Which book did \mathcal{P} read?

- a. Syntax: *wh*-movement leaves a **complex trace** t_i^j . The functional index i is bound by the *wh*-item, and the argument index j is bound by the quantifier.



- b. Semantics: (26) denotes a **family of sub-questions**, each of which quantifies over a set A that is a MWS of \mathcal{P} (inspired by Gr&S). A also restricts the domain of the function \mathbf{f} .

$$\lambda Q. \exists A [MWS(\mathcal{P}, A) \wedge Q = \lambda p. \exists x \exists \mathbf{f} [x \in A \wedge \mathbf{f} \in [A \rightarrow \text{book}_@] \wedge p = \hat{\text{read}}(x, \mathbf{f}(x))]] \\ = \left\{ \left\{ \hat{\text{read}}(x, \mathbf{f}(x)) \mid x \in A, \mathbf{f} \in [A \rightarrow \text{book}_@] \right\} \mid MWS(\mathcal{P}, A) \right\}$$

- (27) a. $\llbracket \text{Which book did every student read?} \rrbracket$
 $= \left\{ \left\{ \hat{\text{read}}(s_1, b_1), \hat{\text{read}}(s_2, b_2), \hat{\text{read}}(s_1, b_2), \hat{\text{read}}(s_2, b_1) \right\} \right\}$
 b. $\llbracket \text{Which book did one of the students read?} \rrbracket$
 $= \left\{ \left\{ \hat{\text{read}}(s_1, b_1), \hat{\text{read}}(s_1, b_2) \right\}, \left\{ \hat{\text{read}}(s_2, b_1), \hat{\text{read}}(s_2, b_2) \right\} \right\}$
 c. $\llbracket \text{Which book did no student read?} \rrbracket$
 $= \{\emptyset\}$

- **Advantages & problems:**

- (i) It inherits the advantages and problems of Gr&S's witness sets-based account.
 (ii) It doesn't explain the domain exhaustivity and pair-list uniqueness effects of the pair-list readings of \forall -*wh*_{SG}-questions.

(28) Which book did every student read?

\rightsquigarrow Every student read a book.

\rightsquigarrow None of the students read more than one book.

Domain exhaustivity

Pair-list uniqueness

³Chierchia subsumes this syntactic asymmetry under the weak crossover constraint. Details omitted.

4.3. Dayal (1996, 2016): function-based Crazy C approach

- **Motivation & Proposal** : In a \forall - wh_{SG} - (or multi- wh_{SG} -) question with a pair-list reading, the object- wh exhibits **functional dependency** relative to the subject- \forall/wh . Thus, Dayal proposes another function-based account which derives pair-list readings of multi- wh questions and \forall -questions uniformly.

– A question denotes a set of propositions. Each proposition is based on a function from the domain of the \forall/wh -subject (viz. $student_{@}$) to the domain of the wh -object (viz. $book_{@}$). In particular, the domain of a \forall -quantifier is extracted as retrieving the unique MWS of the quantifier.

(29) Which book did every student read?/ Which student read which book?

$[Q [DP \text{ which book}]_i [[DP \text{ which/every student}]_j [C_{func}^0 [IP t_j \text{ read } t'_i]]]]$

a. $\llbracket IP \rrbracket = \lambda f_{\langle e,e \rangle} \lambda x_e. \hat{\text{read}}(x, f(x))$

b. $\llbracket C_{func}^0 \rrbracket = \lambda q_{\langle ee, est \rangle} \lambda D \lambda R \lambda p. \exists f \in [D \rightarrow R][p = \cap \lambda p'. \exists x \in D[p' = q(x)(f)]]$

c. $Q = \lambda p. \exists f \in [student_{@} \rightarrow book_{@}][p = \cap \lambda p'. \exists x \in student_{@}[p' = \hat{\text{read}}(x, f(x))]]$
 $= \{\cap\{\hat{\text{read}}(x, f(x)) \mid x \in student_{@}\} \mid f \in [student_{@} \rightarrow book_{@}]\}$

– Applying the ANS_{Dayal} -operator returns the strongest true member in this proposition set.

(30) $ANS_{Dayal}(Q)(w) = \iota p[w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow p \subseteq q]]$

(w : as for the two relevant students $s_1 s_2$, s_1 read only b_1 , and s_2 read only b_2 .)

a. $Q_w = \{\hat{\text{read}}(s_1, b_1) \cap \hat{\text{read}}(s_2, b_2)\}$

(Based on $f = [s_1 \rightarrow b_1, s_2 \rightarrow b_2]$)

b. $ANS_{Dayal}(Q)(w) = \hat{\text{read}}(s_1, b_1) \cap \hat{\text{read}}(s_2, b_2)$

- **Advantages:**

- This account keeps the semantic type of questions low, uniformly $\langle st, t \rangle$. It leaves space for complex constructions such as wh -triangles.
- By virtue of the \cap -closure and the ANS_{Dayal} -operator, this account captures the domain exhaustivity and pair-list uniqueness effects of \forall - wh_{SG} -questions (recall (28)).

(31) (w : as for the two relevant students $s_1 s_2$, s_1 read only b_1 , **but s_2 read both b_1 and b_2 .**)

a. $Q_w = \{\hat{\text{read}}(s_1, b_1) \cap \hat{\text{read}}(s_2, b_1), \hat{\text{read}}(s_1, b_1) \cap \hat{\text{read}}(s_2, b_2)\}$

b. $ANS_{Dayal}(Q)(w)$ is undefined

- **Problems:**

– Technical problems: (i) unconventional meaning of IP and crazy functional C^0 ; (ii) λ -abstracts are isolated from the moved phrases; (iii) it is syntactically impermissible to move a non-interrogative phrase *every student* to the spec of an interrogative CP (Heim 2012).

– Empirical problems:

- Composing pair-list readings of \forall - and multi- wh - questions via the very same LF, this account cannot explain their contrast wrt domain exhaustivity (recall (11) and (12)).
- It over generates \forall -pair-list readings for \exists -questions. Since $\llbracket \text{which student} \rrbracket = \llbracket \text{some student} \rrbracket$, it predicts that the \exists -question (32a) has a \forall -pair-list reading derived through the LF (32b).

(32) a. Which book did some student read?

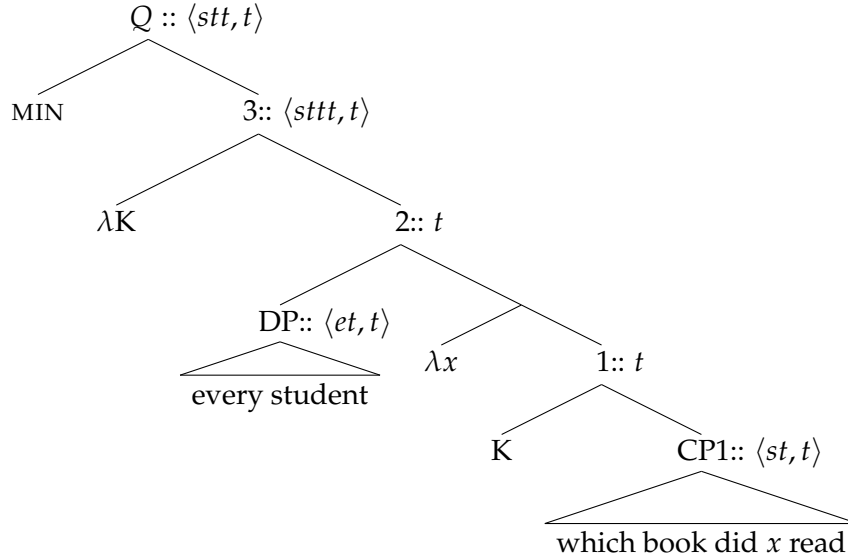
b. $[CP [DP \text{ which book}]_i [[DP \text{ some student}]_j [C_{func}^0 [IP t_j \text{ read } t'_i]]]]$

(iii) It cannot account for the QV inferences in quantified question embeddings: conjuncts of a conjunctive proposition cannot be retrieved out of this proposition (Lahiri 2002)

5. Fox (2012b): family-of-questions approach

- **Proposal:** A \forall -question with a pair-list reading denotes a **family of sub-questions**.
- **Composition:** (i) the \forall -quantifier takes QR and quantifies into a predication (node 1~2); (ii) abstracting a null K-operator returns a set of sets containing all the sub-questions (node 3); (iii) applying a MIN-operator returns the set of sub-questions.

(33) Which book did every student read?



- $\llbracket \text{CP1} \rrbracket = \{ \hat{\text{read}}(x, y) \mid y \in \text{book}_@ \}$
- $\llbracket 1 \rrbracket = K(\{ \hat{\text{read}}(x, y) \mid y \in \text{book}_@ \})$
- $\llbracket 2 \rrbracket = \forall x [x \in \text{student}_@ \rightarrow K(\{ \hat{\text{read}}(x, y) \mid y \in \text{book}_@ \})]$
- $\llbracket 3 \rrbracket = \lambda K. \forall x [x \in \text{student}_@ \rightarrow K(\{ \hat{\text{read}}(x, y) \mid y \in \text{book}_@ \})]$
- $\text{MIN} = \lambda \alpha. \iota K [K \in \alpha \wedge \forall K' \in \alpha [K' \subseteq K]]$
- $Q = \text{MIN}(\llbracket 3 \rrbracket) = \{ \{ \hat{\text{read}}(x, y) \mid y \in \text{book}_@ \} \mid x \in \text{student}_@ \}$

(Pafel 1999)

- **Answerhood:** the (complete true) answer to a family of sub-questions is the conjunction of the (complete true) answers to each sub-question.

$$(34) \quad \text{ANS}_{\text{PW}} = \lambda Q \lambda w. \begin{cases} \text{ANS}_{\text{Dayal}}(Q)(w) & Q \text{ is of type } \langle st, t \rangle \\ \bigcap \{ \text{ANS}_{\text{PW}}(\alpha)(w) : \alpha \in Q \} & \text{otherwise} \end{cases}$$

- **Advantages**

- It inherits the advantages of Dayal in getting domain exhaustivity and point-wise uniqueness.
- It manages to treat the \forall -quantification as a regular \forall -quantification.
- It leaves room for getting QV inferences of quantified question-embedding. The restriction domain of the quantifier is simply the set of sub-questions contained in the question denotation.

- (35) a. Jenny mostly knows [Q which book every student read].
 b. Most Q' [Q' ∈ Q] [Jenny knows Q']

- It captures the limited distribution of pair-list readings: the MIN-operator is undefined whenever the quantifier is not \forall . For instance, (36a-b) do not have a minimal K set.

- (36) a. $\{K: \text{MOST students } x \text{ are such that 'which book did } x \text{ read' is in } K\}$
 b. $\{K: \text{TWO students } x \text{ are such that 'which book did } x \text{ read' is in } K\}$

• **Problems:**

- This account doesn't work for choice readings of \exists -questions: (37) doesn't have a minimal K set.

(37) $\{K: \text{ONE student } x \text{ is such that 'which book did } x \text{ read' is in } K\}$

- Fox (2012ab) predicts that pair-list readings of \forall -questions and multi-*wh*-questions are semantically equivalent, which therefore cannot explain their contrast wrt domain exhaustivity.

6. Summary

• Properties of QiQ

- QiQ readings uniformly exhibit subject-object asymmetry, while pair-list readings of \forall /multi-*wh* questions differ wrt domain exhaustivity.
 – Pair-list readings are only available in \forall -questions. Existing accounts explain this distribution at the cost of not getting choice readings of \exists -questions.
 – In embeddings, \forall /multi-*wh* questions with pair-list readings are subject to QV effects.

• Comparison wrt empirical predictions

Issues/properties	Gr&S (partition)	Gr&S (mws)	Chierchia	Dayal	Fox
Distributing pair-list	✓	✗	✗	✗	✓
\exists -questions	✗	✓	✓	✗	✗
Domain exh of \forall -Q	✓	✓	✗	✓	✓
$[[\forall\text{-Q}] \neq [\text{multi-}wh\text{-Q}]]$	✗	✗		✗	✗
QV effects				✗	✓

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