Getting quantifying-into questions uniformly: Functionality, exhaustivity, and quantificational variability

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Goals and Facts

Goal: To derive quantifying-into questions (QiQ) readings uniformly.

> Which book did Det-kid read?
> ≈ 'For Det-kid x, tell me which book did x read?'

$Q_\forall$	Which book did **every/each** kid read?	Pair-list
$Q_\exists$	Which book did **one/n** of the kids read?	Choice
Q_{NO}	Which book did **none** of the kids read?	N.A.

Fact 1: The distribution of QiQ is preserved with GQ-coordinations.

(1) a. Which toy did [every boy and **one** of the girls] buy? ✓QiQ
b. Which toy did [every boy and **none** of the girls] buy? ✗QiQ

Fact 2: $Q_\forall$ is subject to **domain (D-)exhaustivity**, but $Q_{\text{multi-}wh}$ isn't.

(2) (Context: 200 candidates are competing for 3 job openings.)
a. √ Guess **which** candidate will get which job.
b. # Guess which job **every** candidate will get.

Fact 3: $Q_\forall$-embeddings are subject to **quantificational (Q-)variability**.

(3) **For the most part**, Jenny knows [$_{Q_\forall}$which book every kid read].
a. Most x [x is a kid] [J knows which book x read]
b. Most p [p is a true 'kid-x read book-y' proposition] [J knows p]

Previous studies on $Q_\forall$

Function-based approach (Dayal 1996)

$Q_\forall$ and $Q_{\text{multi-}wh}$ have the same LF and denotation. Each answer is a conjunction naming a function from Dom($\forall$/wh-subj) to Dom(wh-obj).

(4) $Q_\forall / Q_{\text{multi-}wh} = \{\bigcap\{{}^\wedge\mathsf{read}(x,\mathbf{f}(x)) \mid \mathsf{kid}(x)\} \mid \mathbf{f} \in [\mathsf{kid} \rightarrow \mathsf{book}]\}$

Family-of-questions approach (Fox 2012)

$Q_\forall$ and $Q_{\text{multi-}wh}$ have different LFs but the same denotation. $Q_\forall$ is derived via quantifying-into predication and moving MIN.

(5) $Q_\forall / Q_{\text{multi-}wh} = \{[\![\text{which book did } x \text{ read?}]\!] \mid \mathsf{kid}(x)\}$

[MIN λK [every kid λx [K [which book did x read]]]

(The unique minimal K: 'which book did x read' is in K for $\forall$-kid x)

	a. Unifying QiQ	b. D-exhaustivity	c. Q-variability
Dayal	✗	?	✗
Fox	✗	?	✓

a. Both derivations crash in non-$\forall$-questions and cannot extend to $Q_\exists$.
b. Both derive D-exhaustivity for $Q_\forall$ but also for $Q_{\text{multi-}wh}$ (cf. Fact 2).
c. Dayal can't get Q-variability: atomic propositions 'kid-x read book-y' cannot be extracted from their conjunctions. (Lahiri 2002)

Framework: Hybrid categorial approach (Xiang 2016, 2018)

- Questions denote **functions** from short answers to propositional answers.
  ➙ Short answers are extractable from question denotations.
- BeDom turns WhPs from $\exists$-GQs into **polymorphic domain restrictors**.
  ➙ BeDom(whP) can combine with any function of a $\langle e\ldots\rangle$ type and restrict its domain with Dom(whP).

(6) Which book did Ann read?

a. **Individual reading**: 'Which book x is s.t. Ann read x?'
$Q = \lambda x_e : \mathsf{book}(x).{}^\wedge\mathsf{read}(a,x)$ [BeDom(wh-book) λx[Ann read x]]

b. **Functional reading**: 'Which function $\mathbf{f}$ to book is s.t. Ann read $\mathbf{f}$(Ann)?'
$Q = \lambda \mathbf{f}_{\langle e,e\rangle} : \text{Ran}(\mathbf{f}) \subseteq \mathsf{book}.{}^\wedge\mathsf{read}(a,\mathbf{f}(a))$ [BeDom(wh-book) $\lambda\mathbf{f}$[A read $\mathbf{f}$ (A)]]

BeDom(whP) binds a functional trace $\mathbf{f}_{\langle e,e\rangle}$ and restricts its range to Dom(whP).

Proposal

The core idea: QiQ readings are **functional** readings, derived uniformly via **quantifying-into predication** (QiP) and moving the **E-minimizer**.

(7) Which book did Det-kid read? (Det = $\forall$/$\exists$/...)

a. Denotation

$\underbrace{\lambda\mathbf{f}\colon \text{Ran}(\mathbf{f}) \subseteq \mathsf{book}}_{WhP} \wedge \text{Det-kid}\ (\text{Dom}(\mathbf{f})).\ \underbrace{\bigcap E_{\text{MIN}}\{\text{K} \mid \text{Det-kid}\ (\lambda x.\text{K}({}^\wedge x\text{-read-}\mathbf{f}(x)))\}}_{\text{Nucleus}}$

(Input spans $\lambda\mathbf{f}$ … (Dom($\mathbf{f}$)); Output spans $\bigcap E_{\text{MIN}}\{\ldots\}$.)

- Input: functions mapping Det-kid to atomic books.
- Output: conjunctions of minimal proposition sets ranging over Det-kid.

b. Logical Form

[BeDom(wh-book) $\lambda\mathbf{f}\ \bigcap$[E_{MIN} λK [Det-kid λx[K [x read $\mathbf{f}$ (x)]]]]]

Minimization | Quantifying-in | Predication (QiP)

In Nucleus: (i) QiP requires K to include Det-sentence in $\{{}^\wedge x\text{-read-}\mathbf{f}(x) \mid \mathsf{kid}(x)\}$ and $\mathbf{f}$ to be defined for Det-kid. (ii) E_{MIN} returns one of the minimal K sets that fulfill these requirements. (E_{MIN} ≈ Winter's collectivity-raising operator)

Predictions (from nucleus)

	Input	Output	D-exh	pl	ch
$Q_\forall$	...$\forall x \in \mathsf{kid}[x \in \text{Dom}(\mathbf{f})]$	$\bigcap\{{}^\wedge x\text{-read-}\mathbf{f}(x) \mid \mathsf{kid}(x)\}$	+	+	−
$Q_{\exists n}$	...$\exists x \in n\text{-kids}[x \in \text{Dom}(\mathbf{f})]$	$\bigcap\{{}^\wedge x\text{-read-}\mathbf{f}(x)\}$ (for $x \in n$-kids)	−	−	+
Q_{NO}	...$\forall x \in \mathsf{kid}[x \notin \text{Dom}(\mathbf{f})]$	$\bigcap\varnothing$	−	−	−

- [+d-exh] iff $\mathbf{f}$ has to be defined for **every** kid (due to QiP).
- [+pl] iff the minimal K set(s) satisfying QiP are **non-singleton**.
- [+ch] iff there are **multiple** minimal K sets satisfying QiP.

Quantificational variability of $Q_\forall$-embedding

Ans$^{\text{S}}$ extracts the complete true **short** answer (ctsa) of $Q_\forall$ — a function. The restriction of the quantificational adverbial are formed by **atomic functions** that are parts of this ctsa. (cf. Cremers 2018 for composition)

The Q-variability condition
Most $\mathrm{f}'[\mathrm{f}' \in \text{At}(\text{Ans}^{\text{S}}(Q_\forall)(w))]$ $[\mathsf{know}_w(j, \lambda w'.\mathrm{f}' \leq \text{Ans}^{\text{S}}(Q_\forall)(w'))]$
(For most f′ s.t. f′ is ...: J knows that f′ is a part of the ctsa of $Q_\forall$.)

(8) For the most part, J knows [$_{Q_\forall}$ which book did every kid read].
(w: The relevant kids $k_1k_2k_3$ read only $b_1b_2b_3$, respectively.)

a. ctsa of $Q_\forall$

$$\text{Ans}^{\text{S}}(Q_\forall)(w) = \begin{bmatrix} k_1 \rightarrow b_1 \\ k_2 \rightarrow b_2 \\ k_3 \rightarrow b_3 \end{bmatrix}$$

b. Restriction of *for the most part*

$$\text{At}(\text{Ans}^{\text{S}}(Q_\forall)(w)) = \left\{ \begin{matrix} [k_1 \rightarrow b_1] \\ [k_2 \rightarrow b_2] \\ [k_3 \rightarrow b_3] \end{matrix} \right\}$$

c. The Q-variability condition is true ...
iff J's belief entails the union of the following seven partition cells;
iff Most $\mathrm{f}'[\mathrm{f}' \in \text{At}(\text{Ans}^{\text{S}}(Q_\forall)(w))]$ $[\mathsf{know}_w(j, \bigcap\{{}^\wedge\mathsf{read}(x,\mathrm{f}'(x)) \mid \mathsf{kid}(x)\})]$

	$k_1 \rightarrow b_2$, $k_2 \rightarrow b_2$, $k_3 \rightarrow b_3$	$k_1 \rightarrow b_3$, $k_2 \rightarrow b_2$, $k_3 \rightarrow b_3$
$k_1 \rightarrow b_1$, $k_2 \rightarrow b_1$, $k_3 \rightarrow b_3$	$k_1 \rightarrow b_1$, $k_2 \rightarrow b_2$, $k_3 \rightarrow b_3$	$k_1 \rightarrow b_1$, $k_2 \rightarrow b_3$, $k_3 \rightarrow b_3$
$k_1 \rightarrow b_1$, $k_2 \rightarrow b_2$, $k_3 \rightarrow b_1$	$k_1 \rightarrow b_1$, $k_2 \rightarrow b_2$, $k_3 \rightarrow b_2$	

Appendix

(9) Answerhood in proposition-based approaches (Dayal and Fox)
a. $\text{Ans}(Q_{\langle st,t\rangle})(w) = \iota p[w \in p \in Q \wedge \forall q[w \in q \in Q \rightarrow p \subseteq q]]$
b. $\text{Ans}_{\text{pw}}(Q_{\langle stt,t\rangle})(w) = \bigcap\{\text{Ans}(Q')(w) \mid Q' \in Q\}$

(10) Answerhood in categorial approaches (Xiang)
a. $\text{Ans}^{\text{S}}(Q_{\langle\tau,st\rangle})(w) = \iota\alpha \begin{bmatrix} \alpha \in \text{Dom}(Q) \wedge w \in Q(\alpha) \\ \wedge\forall\beta \begin{bmatrix} \beta \in \text{Dom}(Q) \wedge w \in Q(\beta) \\ \rightarrow Q(\alpha) \subseteq Q(\beta) \end{bmatrix} \end{bmatrix}$
b. $\text{Ans}(Q_{\langle\tau,st\rangle})(w) = Q(\text{Ans}^{\text{S}}(Q)(w))$

(11) Minimizers: minimum vs minimal
a. $\text{MIN} = \lambda\alpha.\iota\text{K}[\text{K} \in \alpha \wedge \forall\text{K}' \in \alpha[\text{K} \subseteq \text{K}']]$ (Pafel 1999)
b. $E_{\text{MIN}} = \lambda\alpha.f_{\text{CH}}\{\text{K} \mid \text{K} \in \alpha \wedge \forall\text{K}' \in \alpha[\text{K}' \not\subset \text{K}]\}$

(12) The BeDom-shifter
$$\text{BeDom}(\mathcal{P}) = \lambda\theta_\tau.\iota P_\tau \begin{bmatrix} [\text{Dom}(P) = \text{Dom}(\theta) \cap \text{Be}(\mathcal{P})] \\ \wedge\ \forall\alpha \in \text{Dom}(P)[P(\alpha) = \theta(\alpha)] \end{bmatrix}$$

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