Short answers as tests:
A post-suppositional view on *wh*-questions and answers

Linmin Zhang
NYU Shanghai / 567 West Yangsi Road, Shanghai, 200126, China
linmin.zhang@nyu.edu, zhanglinmin@gmail.com

Abstract

This paper explores a post-suppositional view on *wh*-questions and their answers with dynamic semantics. I propose a unified treatment of items like modified numerals, focus items, and *wh*-items: they introduce a discourse referent (dref) in a non-deterministic way and then impose definiteness tests in a delayed, post-suppositional manner at the sentential level. Thus, by asking a question like *who smiled*, we get the (maximally informative) dref 'the one(s) who smiled'. An answer like '*Mary and Max*' is considered another post-suppositional test, checking whether the dref 'the one(s) who smiled' is identical to the sum **Mary⊕Max**. I analyze various question-related phenomena to see how far this proposal can go.

1 Introduction

This paper explores a post-suppositional view on the semantics of *wh*-questions and answers within a dynamic semantics framework.

For a *wh*-question like (1), it is easy to see that the short answer in (1a) is guaranteed to be a complete true answer, and the corresponding propositional answer is actually tautological. However, despite its being true and complete, interlocutors usually don't accept such an answer, because it is derivable from the question and provides no new information. In contrast, (1b) illustrates what a typical acceptable short answer should look like.

(1) Who smiled?

a. The one(s) who smiled. Short Ans.
$\rightsquigarrow$ The one(s) who smiled smiled.

b. Mary and Max. Short Ans.
$\rightsquigarrow$ Mary and Max smiled.

The above observation suggests that a good short answer to a *wh*-question provides new information about **something definite** that has already been established and restricted by the *wh*-question. Thus this observation is reminiscent of existing literature on some **post-suppositional** phenomena, i.e., delayed tests that check / provide additional information about something definite.

Brasoveanu (2013) provides a post-supposition-based account for modified numerals in cumulative-reading sentences.[1]

(2) $\underline{\text{Exactly } 3^u \text{ boys}}$ saw $\underline{\text{exactly } 5^\nu \text{ movies}}$.
Cumulative reading of (2):

$$\underbrace{\sigma x \sigma y[\text{BOY}(x) \wedge \text{MOVIE}(y) \wedge \text{SEE}(x, y)]}_{\text{the mereologically maximal } x \text{ and } y \text{ satisfying these restrictions}}$$

$$\underbrace{\wedge\, |y| = 5 \wedge |x| = 3}_{\text{cardinality tests}}$$

(σ: maximality operator; for notation simplicity, cumulative closure is assumed.)

As sketched out in (2), the semantic contribution of modified numerals (i.e., the underlined parts) includes several layers:

Modified numerals first introduce, in a non-deterministic way, (potentially plural) discourse referents (drefs), x and y (assigned to u and ν respectively). After various relevant restrictions are added onto these drefs (here $\text{BOY}(x)$, $\text{MOVIE}(y)$, and $\text{SEE}(x, y)$), modified numerals further contribute maximality tests and cardinality tests.

The maximality operators σ pick out the mereologically maximal x and y, i.e., x that is equal to the sum of all boys who saw any movies, and y that is equal to the sum of all movies seen by any boys.

These mereologically maximal drefs are finally checked for their cardinality. Therefore, eventually, (2) addresses the cardinality of all the boys who saw any movies (which is 3) and the cardinality of all the movies seen by any boys (which is 5).

What cardinality tests do in a cumulative-reading sentence is exactly parallel to what a good short an-

[1] Sentence (2) also has a distributive reading, which is not discussed in this paper (see also Brasoveanu 2013).

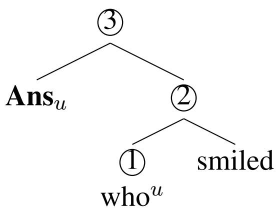
swer like (1b) does to a *wh*-question. For both cumulative-reading sentences and *wh*-questions, we start from non-deterministic alternatives and then arrive at the definite one that interests us the most (e.g., some mereologically maximal drefs, something that represents the complete true answer), and cardinality tests or good short answers provide additional information to this definite dref. Thus, in this paper, I explore this parallelism and propose a novel post-suppositional view on *wh*-questions and answers.

The rest of the paper is organized as follows. Section 2 presents the main proposal with a dynamic semantics formalism à la Bumford (2017). Section 3 explores further extensions of the proposal, analyzing various empirical phenomena hotly discussed in the existing literature on question semantics. Section 4 briefly compares the current work with recent related works. Section 5 concludes.

2 Proposal: *Wh*-questions and answers

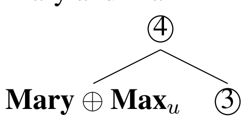
As illustrated in (3) and (4), I propose a post-suppositional account for *wh*-questions and their short answers and implement the analysis with a dynamic semantics formalism à la Bumford (2017).

(3) Who^u smiled? ***wh*-question**



①: Introducing drefs:
① $= [\![\text{who}^u]\!] = [\![\text{some}^u \text{ (people)}]\!]$
$= \lambda g\,.\,\{g^{u\mapsto x} \mid \textsc{human}(x)\}$
②: More restrictions are added:
② $= [\![\text{who}^u \text{ smiled}]\!]$
$= [\![\text{some}^u \text{ (people) smiled}]\!]$
$= \lambda g\,.\,\{g^{u\mapsto x} \mid \textsc{hmn}(x) \wedge \textsc{sml}(x)\}$
③: Applying maximality tests:
③ $= \mathbf{Ans}_u(②) =$
$\lambda g\,.\,\{g^{u\mapsto x} \mid x = \Sigma x[\textsc{hmn}(x) \wedge \textsc{sml}(x)]\}$

(4) Mary and Max **short answer to (3)**



④: Checking additional information
④ $= \mathbf{Mary} \oplus \mathbf{Max}_u(③) =$
$\lambda g\,.\,\{g^{u\mapsto x} \mid x = \Sigma x[\textsc{hmn}(x) \wedge \textsc{sml}(x)]\}$,
if $x = \mathbf{Mary} \oplus \mathbf{Max}$ (or $x \sqsupseteq \mathbf{Mary} \oplus \mathbf{Max}$)

(5) **Maximality test** (informativeness-based):
$\mathbf{Ans}_u \overset{\text{def}}{=} \lambda m.\lambda g\,.$
$\{h \in m(g) \mid \neg\exists h' \in m(g)\,.\,G(h(u)) <_{\text{info}} G(h'(u))\}$
(G is a context-dependent measurement function of informativeness.)[2]

a. Mereological maximality as a special case: $\mathbf{Ans}_u \overset{\text{def}}{=} \lambda m.\lambda g\,.$
$\{h \in m(g) \mid \neg\exists h' \in m(g)\,.\,h(u) \sqsubset h'(u)\}$

(6) **Good short answer as another test**:

a. As a complete answer:
$\mathbf{Mary} \oplus \mathbf{Max}_u \overset{\text{def}}{=}$
$\lambda m.\lambda g\,.\,m(g)$, if $g(u) = \mathbf{My} \oplus \mathbf{Mx}$
(if not, this returns $\emptyset$)

b. As a potentially partial answer:
$\mathbf{Mary} \oplus \mathbf{Max}_u \overset{\text{def}}{=}$
$\lambda m.\lambda g\,.\,m(g)$, if $g(u) \sqsupseteq \mathbf{My} \oplus \mathbf{Mx}$
(if not, this returns $\emptyset$)

Within dynamic semantics, meaning derivation is considered a series of updates from one information state to another, and an information state m (of type $g \to \{g\}$) is considered a function from an input assignment function to an output set of assignment functions (see Bumford 2017). An update is true if the output set of assignment functions is not an empty set; an update is false if the output set of assignment functions is an empty set.

In (3), *who*^{u} first works like an indefinite and introduces a dref in a non-deterministic way. Given that the domain of this *wh*-item, *who*, is typically a set of human individuals, I also include the restriction $\textsc{human}(x)$ here (see ① in (3)).

After other relevant restrictions are added (here $\textsc{smile}(x)$, see ② in (3)), an operator $\mathbf{Ans}_u$ is applied to ② (see (5) and ③ in (3)), picking out the definite dref that eventually leads to the maximally informative true answer to the *wh*-question.

Obviously, in this specific example (3), where the domain of the *wh*-item is a set of individuals and the predicate *smile* is inherently distributive, $\mathbf{Ans}_u$ amounts to picking out the mereologically maximal dref, as shown in (5a). Essentially, ② means 'someone that smiled (smiled)', and ③ means 'the one(s) who smiled (smiled)'.

(4) illustrates how a good short answer works. As defined in (6), $\mathbf{Mary} \oplus \mathbf{Max}_u$ plays the same role as cardinality tests do in a cumulative-reading sentence (see (2)). If $\mathbf{Mary} \oplus \mathbf{Max}_u$ is a complete

[2] See further discussion below on degree questions (Section 2.5). See also Zhang (2023) for more discussion on maximal informativeness.

answer, this test checks whether the maximal dref in ③ is identical to the sum **Mary** $\oplus$ **Max**$_u$. If **Mary** $\oplus$ **Max**$_u$ is a potentially partial answer, this test checks whether the sum **Mary** $\oplus$ **Max**$_u$ is part of the maximal dref in ③.

Basically, the above analysis shows (i) a compositional derivation of the meaning of a *wh*-question, (ii) the derivation of its (analytically) maximally informative true answer, and (iii) how a good short answer contributes information in addressing the *wh*-question. This analysis inherits many existing insights on question meanings.

2.1 Cross-sentential anaphora

Wh-items are parallel to indefinites in introducing drefs and supporting cross-sentential anaphora, as illustrated in (7) (see e.g., Comorovski 2013).

(7) a. Someone^u smiled. Did they$_u$ get the joke?
  b. Who^u smiled? Did they$_u$ get the joke?

These behaviors and the parallelism between *wh*-items and indefinites are immediately explained in the current dynamic-semantics-based framework. Actually, in (3), ② represents the meaning of both the *wh*-question *who smiled* and the declarative sentence *someone smiled.*

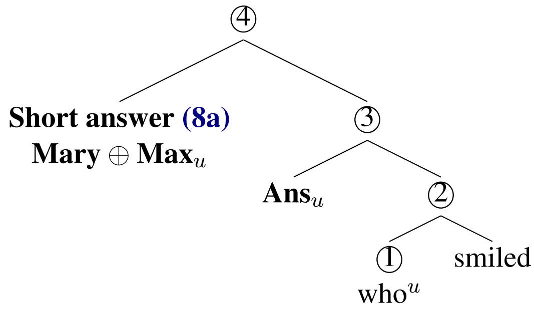
2.2 Short answers and the categorial approach

According to the categorial approach to *wh*-questions (Hausser and Zaefferer 1978), a *wh*-question denotes a function, which, when applying to its short answer, generates a (potentially complete true) propositional answer (see (8)).

(8) Categorial approach:
  $[\![\text{who smiled}]\!] = \lambda x.\text{SMILE}(x)$
  a. Short answer: Mary and Max
  b. Propositional answer:
    [Mary and Max]$_F$ smiled.

Similar to the categorial approach, the current post-suppositional analysis also composes a short answer with question meaning to derive the meaning of the corresponding propositional answer. As shown in (9), when the short answer **Mary**$\oplus$**Max**$_u$ (see (6)) is applied to the question meaning (see ③ in (3)), the meaning of the propositional answer (8b) is naturally derived (see also ④ in (4)).

(9) **Propositional answer (8b)**



Thus, under both the current analysis and the categorial approach, short answers are not derived from propositional analysis via ellipsis.

Jacobson (2016) also argues for the view that short answers do not contain hidden, elided linguistic materials. The current analysis for short answers is in line with this view. The analysis in (6) does not contain any ellipsis, and it only indicates (i) with which dref in the *wh*-question the sum **Mary** $\oplus$ **Max**$_u$ is connected and (ii) whether this connection is an identity relation or a part-whole relation. Actually sometimes this distinction between a complete and a potentially partial short answer can be reflected by intonation.

The current analysis overcomes a few issues that challenge the original categorial approach.

As pointed out by Xiang (2021), under the traditional categorial approach, a *wh*-item is considered a λ-operator, thus this analysis fails to show the parallelism between *wh*-items and indefinites, which is widely observed cross-linguistically. Under the current analysis, *wh*-items are analyzed in exactly the same way as indefinites (see ① in (3)).

Xiang (2021) points out that the traditional categorial approach also faces the issues of (i) composing multi-*wh*-questions and (ii) question coordination. Section 3 will show how the above analysis can be extended to handle these issues.

2.3 Karttunen (1977): A *wh*-question means its complete true answer

The current analysis of *wh*-questions is also in the same spirit as Karttunen (1977): A *wh*-question has the same meaning as its complete true answer. This can be seen from ③ in (3).

According to Dayal (1996)'s Maximal Informativity Presupposition, a question presupposes the existence of a maximally informative true answer. Thus as far as a *wh*-question meets this requirement, the operator **Ans**$_u$ (see (5)) is applicable to something like ② in (3), and ③ is derivable, which corresponds to the complete true answer. In other words, semantically, a *wh*-question is guaranteed to have an analytical complete true answer.

Different from Karttunen (1977), Hamblin (1973) analyzes the meaning of a *wh*-question as its possible propositional answers, instead of true propositional answers. Dependency data like (10) seem to support Hamblin (1973)'s view (see Dayal 2016), because according to our intuition, for (10), the interpretation of *where is Mary* has to be a Hamblin set, i.e., a set of possible answers that address where Mary is. For this kind of dependency data, I'll account for them in Section 3.4 while maintaining a view in line with Karttunen (1977).

(10) What does John think? Where is Mary?
$\rightsquigarrow$ Where does John think Mary is?
(see, e.g., Dayal 2016)

2.4 The parallelism between *wh*-questions and *wh*-free-relatives

The current analysis also explains the parallelism between *wh*-questions and *wh*-free-relatives (see Caponigro 2003, 2004; Chierchia and Caponigro 2013). Essentially, a *wh*-free-relative can be considered the analytically true, definite, complete short answer to its corresponding *wh*-question.

As illustrated in (11), *wh*-free-relatives can be replaced by a definite DP, and (11a) and (11b) have the same truth condition. The analysis in (12) explains this truth-conditional equivalence. In (12), $\mathbf{Ans}_u$ plays the same role as a mereological maximality operator, leading to the maximal sum of things cooked by Adam (see (5a)).

(11) a. Jie tasted what^u Adam cooked.
(from Caponigro 2004)
b. Jie tasted the^u things Adam cooked.

(12) $[\![\text{what}^u \text{ Adam cooked}]\!]$
$= \mathbf{Ans}_u(\lambda g.\ \{g^{u\mapsto x} | \textsc{cook}(\text{Adam}, x)\})$
$= \lambda g.\ \{g^{u\mapsto x} |\ x = \Sigma x[\textsc{cook}(\text{Adam}, x)]\}$
$= [\![\text{the}^u \text{ things Adam cooked}]\!]$

A further issue is about mention-some questions.

(13) Who can help her?

(14) Mary was looking for who can help her.
$=$ Mary was looking for someone that can help her.
$\neq$ Mary was looking for all the people that can help her.

As illustrated in (13) and (14), in these examples, there is also a parallelism between mention-some *wh*-questions (see (13)) and mentions-some *wh*-free-relatives (see (14)). However, it seems that mereological maximality is not involved.

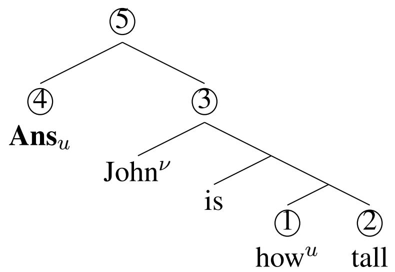
Actually, in (5), I consider $\mathbf{Ans}_u$ a maximality operator that leads to the most informative answer. Maximal informativeness is not necessarily based on mereological maximality (see Zhang 2023).

Thus for mention-some *wh*-questions and *wh*-free-relatives, the specific implementation of $\mathbf{Ans}_u$ should be different from the mereology-based one defined in (5a). Presumably, the application of $\mathbf{Ans}_u$ should involve (i) a context-relevant measurement of informativeness that takes into consideration the accessibility or availability of resources and/or (ii) some free-choice operator. I leave a detailed development of this idea for future research.

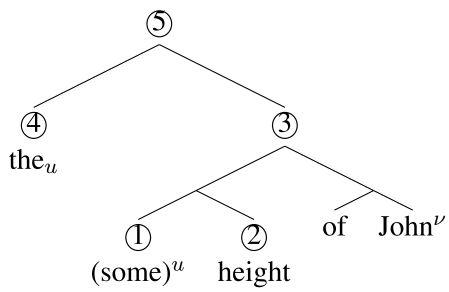
2.5 The parallelism between *wh*-questions and concealed questions

The current analysis also naturally captures the parallelism between *wh*-questions and concealed questions. Syntactically, a concealed question looks like a definite DP, but semantically, it works like a *wh*-question (see, e.g., Nathan 2006). In (15) and (16), the content of what Mary knows is expressed as a *wh*-question in (15) and as a concealed question in (16). (17) shows their parallel derivation.

(15) Mary know how^u tall John$^\nu$ is.
She thinks that Bill is shorter than that$_u$.



(16) Mary know the^u height of John$^\nu$.
She thinks that Bill is shorter than that$_u$.



(17) ① $= \lambda g.\ \{g^{u\mapsto I} | \textsc{Interval}(I)\}$
② $= \lambda I \lambda x.\textsc{height}(x) \subseteq I$

(i.e., the height measurement of x falls into the interval I.)

③ $= \lambda g.\, \left\{ g^{\overset{u\mapsto I}{\nu\mapsto x}} | \text{HEIGHT}(x) \subseteq I, x = \text{J} \right\}$

④ $= \mathbf{Ans}_u \overset{\text{def}}{=} \lambda m.\lambda g.$
$\{h \in m(g) \mid \neg\exists h' \in m(g)\,.\, h'(u) \subset h(u)\}$

⑤
$= \mathbf{Ans}_u(\lambda g.\, \left\{ g^{\overset{u\mapsto I}{\nu\mapsto x}} | \text{HT}(x) \subseteq I, x = \text{J} \right\})$
$= \lambda g.\, \left\{ g^{\overset{u\mapsto I}{\nu\mapsto x}} |\ I = \iota I[\text{HT}(\text{J}) \subseteq I], x = \text{J} \right\}$

In both cases, the semantic contribution of *the* and *how* can be considered two-fold. They (i) first introduce a dref in the domain of degrees or intervals (which supports cross-sentential anaphora later)[3] and (ii) then impose a definiteness test, leading to maximal informativeness.[4] Thus the most informative interval in which the height measurement of John falls is selected out (e.g., $[5'11'', 5'11'']$, if the measurement is very precise). In this case, since the domain of the dref is not a set of individuals, but a set of intervals, the specific implementation of $\mathbf{Ans}_u$ (see ④ in (17)) is not mereology-based.

3 Further extensions

Now I sketch out how the proposal can be extended to account for more question-related phenomena.

3.1 Strong vs. weak exhaustivity

Among various theories on question semantics, Partition Semantics (Groenendijk and Stokhof 1982, 1984, 1990) is motivated by a distinction between a strong vs. a weak exhaustive reading of sentences like (18).

Under the weak exhaustive reading, (18) means that Mary has the complete knowledge about all walkers (see (18a)). Under the strong exhaustive reading, (18) means that Mary has the complete knowledge about everyone in the domain, including all walkers and non-walkers (see (18b)).

(18) Mary knows <u>who^u walks</u>.

a. If x walks, Mary knows x walks. **W**

b. For each individual x in the domain, Mary knows whether x walks. **S**

To capture the strong exhaustive reading, Partition Semantics analyzes a question as a partition on possible worlds. The current proposal can also be extended to capture this strong exhaustive reading.

As shown in (19), the embedded *wh*-question in (18) is analyzed in the same way as a matrix *wh*-question, yielding the sum of all those who walk, which is assigned to u.

Then the part *Mary knows* works like a post-suppositional test, providing additional information on $g(u)$. For the weak exhaustive reading, as shown in (20), **Mary knows**$_{\text{weak }u}$ checks for each part of $g(u)$, x', whether the part-whole relation '$x' \sqsubseteq g(u)$' is known by Mary. For the strong exhaustive reading, as shown in (21), **Mary knows**$_{\text{strong }u}$ checks (i) for each part of $g(u)$, x', whether the part-whole relation '$x' \sqsubseteq g(u)$' is known by Mary, and (ii) for each x' that is not part of $g(u)$, whether '$x' \not\sqsubseteq g(u)$' is known by Mary. In (20) and (21), $\mathfrak{Know}_{\mathfrak{M}}$ is considered of type $\langle tt\rangle$, a set of items of type t.

(19) $[\![(18)]\!] =$
Mary knows$_u$(**Ans**$_u$($[\![$who^u walks$]\!]$))
Ans$_u$($[\![$who^u walks$]\!]$) $=$
$\lambda g.\, \{g^{u\mapsto x} |\ x = \Sigma x[\text{HMN}(x) \wedge \text{WALK}(x)]\}$

(20) **Weak exhaustivity reading**:
Mary knows$_{\text{weak }u}$ $\overset{\text{def}}{=}$ $\lambda m.\lambda g.m(g)$ if $\forall x'[x' \sqsubseteq g(u) \rightarrow \mathfrak{Know}_{\mathfrak{M}}(x' \sqsubseteq g(u))]$
(i.e., for any x' in the domain, if x' walks, then Mary knows x' walks.)

(21) **Strong exhaustivity reading**:
Mary knows$_{\text{strong }u}$ $\overset{\text{def}}{=}$ $\lambda m.\lambda g.m(g)$ if $\forall x'[[x' \sqsubseteq g(u) \rightarrow \mathfrak{Know}_{\mathfrak{M}}(x' \sqsubseteq g(u))] \wedge [x' \not\sqsubseteq g(u) \rightarrow \mathfrak{Know}_{\mathfrak{M}}(x' \not\sqsubseteq g(u))]]$
(i.e., for any x' in the domain, Mary knows whether x' walks.)

Quantificational variability can be captured in the same way, as illustrated in (22) and (23). In (23), the test **Mary knows**$_{\text{part }u}$ checks whether for some part of $g(u)$, x', the part-whole relation '$x' \sqsubseteq g(u)$' is known by Mary.

(22) **Quantificational variability**:
Mary partly knows <u>who^u walks</u>.

(23) **Mary knows**$_{\text{part }u}$ $\overset{\text{def}}{=}$ $\lambda m.\lambda g.m(g)$ if $\exists x'[x' \sqsubseteq g(u) \wedge \mathfrak{Know}_{\mathfrak{M}}(x' \sqsubseteq g(u))]$

Under the current proposal, the question meaning itself and its analytical answer always remain the same (see (19)). What varies is what is included in Mary's knowledge. The current analysis also reflects the extensionality of knowledge: What is

[3] An interval is a convex set of degrees, e.g., $[5', 5']$, $[5', 6']$. (Schwarzchild and Wilkinson 2002; Zhang and Ling 2021).

[4] See Bumford (2017) for the idea that the meaning of *the* includes an indefinite part. This idea can be dated back to Russell (1905).

included in Mary's knowledge does not affect or change the answer to the *wh*-question itself.

Even if different possible worlds have different walkers, (i) the way how the analytical answer to a *wh*-question is characterized and (ii) the way how somebody's knowledge is connected to this analytical answer are stable across different possible worlds. Thus the meaning of sentences like (18) should be the same at every world, and the current analysis captures this stability.

3.2 Question coordination

Xiang (2021) points out that the traditional categorial approach to *wh*-questions is challenged by question coordination. For a sentence like (24), the traditional approach predicts that it has the same meaning as *Jenny knows who voted for Andy and Bill* (see (25)), and this prediction is inconsistent with our intuitive interpretation for (24).

(24) Jenny knows who^{u_1} voted for Andy and who^{u_2} voted for Bill. (see Xiang 2021)

(25) Traditional categorial approach:
$[\![$who voted for Andy and who voted for Bill$]\!]$
$= \lambda x.\textsc{vote}(x, \text{A}) \sqcap \lambda x.\textsc{vote}(x, \text{B})$
$= \lambda x.[\textsc{vote}(x, \text{A}) \wedge \textsc{vote}(x, \text{B})]$
$= [\![$who voted for Andy and Bill$]\!]$

Under the current analysis, for (24), the two *wh*-items each introduce a dref and different restrictions are applied to the two drefs respectively. Then two **Ans** operators are applied, selecting out the maximal drefs (see (26)). Finally, (27) shows that Jenny has the (weak) exhaustive knowledge about these two maximal drefs. In her knowledge, each dref is tracked individually.

(26) $\textbf{Ans}_{u_1}([\![\text{who}^{u_1} \text{ voted for Andy}]\!])$
$\wedge \textbf{Ans}_{u_2}([\![\text{who}^{u_2} \text{ voted for Bill}]\!])$
$= \lambda g.\{g^{\substack{u_1\mapsto x\\ u_2\mapsto y}} \mid x = \Sigma x[\textsc{hmn}(x) \wedge \textsc{vt}(x, \text{A})], y = \Sigma y[\textsc{hmn}(y) \wedge \textsc{vt}(y, \text{B})]\}$

(27) $\textbf{Jenny knows}_{\text{weak } u_1, u_2, \ldots} \overset{\text{def}}{=} \lambda m.\lambda g.m(g)$
if for each variable $u_i \in \{u_1, u_2, \ldots\}$,
$\forall x'[[x' \sqsubseteq g(u_i) \rightarrow \mathfrak{Know}_{\mathfrak{J}}(x' \sqsubseteq g(u_i))]]$

3.3 *Wh*-conditionals

The above idea on question coordination can be further extended to sentences with multi *wh*-items.

(28) Who^{u} comes depends on who$^{\nu}$ is invited.

(29) $\textbf{depend-on}_{u,\nu} \overset{\text{def}}{=} \lambda m.\lambda g.m(g)$ if
$\exists f.f(g(\nu)) = g(u)$

A sentence like (28) addresses the correlation between the answers to two *wh*-questions. The answer to the question *who^{u} comes* correlates with or depends on the answer to the question *who$^{\nu}$ is invited*. As proposed in (29), $\textbf{depend-on}_{u,\nu}$ works as a post-suppositional test, checking whether there is a function f mapping the maximal dref assigned to ν, $g(v)$, to the maximal dref assigned to u, $g(u)$.

Wh-conditionals in Mandarin Chinese can be accounted for in exactly the same way.

According to Liu (2017); Xiang (2021); Li (2019, 2021), a *wh*-conditional sentence like (30) includes two questions, here *who^{u} loses* and *who$^{\nu}$ pays*, and the short answer to the first *wh*-question is equivalent to the short answer to the second one (cf. Xiang 2021). As shown in (31) and (32), this intuitive reading is naturally accounted for.

(30) Shéi^{u} shū-le, shéi$^{\nu}$ (jiù) qǐngkè
who lose-ASP who (then) pay
'For every person x, if x is the one losing the bet, x is the one paying.' (see Li 2021)

(31)
[$\textbf{Eq}_{u,\nu}$ [① [$\textbf{Ans}_{u}$ [shéi^{u} shū-le / who^{u} loses]] [$\textbf{Ans}_{\nu}$ [shéi$^{\nu}$ qǐngkè / who$^{\nu}$ pays]]]]

① $= \lambda g.\{g^{\substack{u\mapsto x\\ \nu\mapsto y}} \mid x = \Sigma x[\textsc{hmn}(x) \wedge \textsc{lose}(x)], y = \Sigma y[\textsc{hmn}(y) \wedge \textsc{pay}(y)]\}$

(32) $\textbf{Eq}_{u,\nu} = \lambda m.\lambda g.m(g)$ if $g(u) = g(\nu)$

More general cases of *wh*-conditionals, including those involving degree questions, can also be accounted for. (33) means that the amount of food you eat determines the amount of money you pay, i.e., the answer to the first degree question determines the answer to the second one.

(33) chī duō-shǎo$^{u_1,\nu_1}$, fù duō-shǎo$^{u_2,\nu_2}$
eat how.much pay how.much
'How much (you) eat, how much (money you) pay.' (see Liu 2017; cf. Xiang 2021)

(34) $\lambda g.\{g^{\substack{u_1\mapsto x, \nu_1\mapsto I_1\\ u_2\mapsto y, \nu_2\mapsto I_2}} \mid x = \Sigma x[\textsc{fd}(x)], y = \Sigma y[\textsc{mn}(y)], I_1 = \textsc{am}(x), I_2 = \textsc{am}(y)\}$

(35) $\textbf{determine}_{\nu_1,\nu_2} = \lambda m.\lambda g.m(g)$ if
$\exists f.f(g(\nu_1)) = g(\nu_2)$

For (33), I assume that each degree question introduces two drefs: one in the domain of e (here x and y), and the other one in the domain of intervals (here I_1 and I_2). (34) shows that the most informative drefs are picked out: the mereologically maximal x and y, and the most informative amount measurement of x and y, I_1 and I_2. Obviously, I_1 and I_2 are the most informative answers to the two *wh*-questions in (33). Finally, similar to (29), a silent operator $\textbf{determine}_{\nu_1,\nu_2}$ works as a post-suppositional test, checking whether there is a context relevant function f that maps $g(\nu_1)$ to $g(\nu_2)$. The operator $\textbf{Eq}_{u,\nu}$ (32) can be considered a special case of the operator $\textbf{determine}_{\nu_1,\nu_2}$ in (35).

3.4 Question dependency

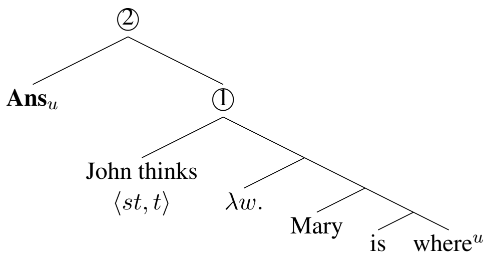
Syntactically, there are two subtypes of question dependency: direct dependency (see (36)) and indirect dependency (see (37)). Semantically, they have the same meaning. Based on their syntactic differences, Dayal (1994, 2016) advocate distinct analyses to derive their meaning. Here I follow this desideratum to address question dependency.

(36) Where^u does John think Mary is?

(37) What$^\nu$ does John think? Where^u is Mary?

As shown in (38), the derivation of direct dependency is straightforward. *Wh*-item *where*^{u} introduces a dref, and the application of the definiteness test $\textbf{Ans}_u$ is delayed until the matrix sentence level. $[\![$John thinks$]\!]$ is of type $\langle st, t\rangle$, restricting items of type $\langle st\rangle$. Eventually, (36) denotes the most informative dref x such that John thinks Mary is in x. Obviously, this dref x does not necessarily satisfy the restriction 'IN(Mary, x)', capturing the intensionality of attitude-reporting predicate *think*.

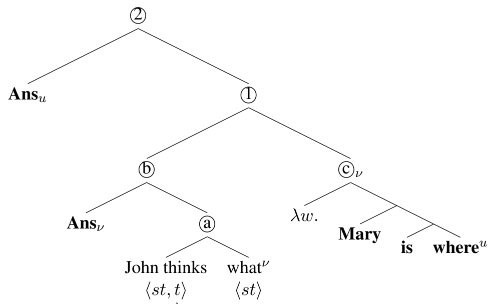
(38)



① $= \lambda g\,.\,\{g^{u\mapsto x} |\ \text{LOCATION}(x),$ $\text{JOHN-THINKS}(\lambda w.\text{IN}(\text{Mary}, x))\}$
② $= \lambda g\,.\,\{g^{u\mapsto x} |\ x = \iota x[\text{LCT}(x) \wedge$ $\text{JOHN-THINKS}(\lambda w.\text{IN}(\text{Mary}, x))]\}$

Then as shown in (39), for (37), I propose that *what*$^\nu$ introduces a dref of type $\langle st\rangle$, and *where*^{u} introduces a dref of type e. As shown in ⓑ, the part of the *what*$^\nu$ question denotes the most informative proposition p satisfying $\text{JOHN-THINKS}(p)$. Then as shown in ⓒ, the *where*^{u} question works as a test and provides further information on p, introducing a dref x and checking whether this most informative p entails a propositional that addresses Mary is somewhere. The rest is similar to the case of direct dependency. Eventually, (37) also denotes the most informative dref x such that John thinks Mary is in x, i.e., the same meaning as (36).

(39)



ⓐ $= \lambda g\,.\,\{g^{\nu\mapsto p} |\ \text{JOHN-THINKS}(p)\}$
ⓑ $= \textbf{Ans}_\nu$(ⓐ) $=$
$\lambda g\,.\,\{g^{\nu\mapsto p} |\ p = \cap p[\text{JOHN-THINKS}(p)]\}$
ⓒ$_\nu = [\![\lambda w.\textbf{Mary is where}^u]\!]_\nu =$
$\lambda m.\lambda g.m(g)$ if $g(u) \mapsto x$ s.t. $\text{LCT}(x) \wedge$
$g(\nu) \subseteq \lambda w.\text{IN}(\text{Mary}, x)$
① $= \lambda g\,.\,\{g^{\overset{u\mapsto x}{\nu\mapsto p}} |\ \text{LC}(x), p = \cap p[\text{J-T}(p)],$
$\text{JOHN-THINKS}(\lambda w.\text{IN}(\text{Mary}, x))\}$
② $= \lambda g\,.\,\{g^{\overset{u\mapsto x}{\nu\mapsto p}} |\ p = \cap p[\text{J-T}(p)], x =$
$\Sigma x[\text{LCT}(x) \wedge \text{J-T}(\lambda w.\text{IN}(\text{Mary}, x))]\}$

The current analysis of question dependency is still in line with Karttunen (1977): A *wh*-question denotes its complete true answer, not its possible answers (see Section 2.3). With this dynamics semantics implementation, the derivation always starts with non-determinate alternatives, and it is the application of **Ans** operators that results in definite, complete true answers. In (39), $\textbf{Ans}_u$ is not applied on ⓒ, thus the derivation never yields a Hamblin set for *where*^{u} *is Mary*.

3.5 Multi-*wh*-questions

A multi-*wh*-question has two readings, e.g.,

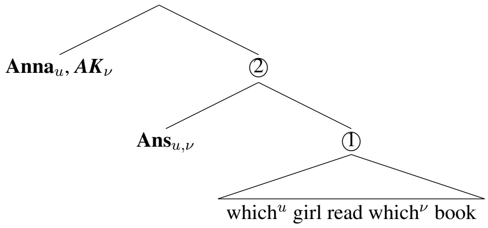
(40) Which girl read which book?

a. **Single-pair reading**:
Anna read *Anna Karenina*.

b. **Pair-list reading**: Anna read *Anna Karenina*; Emma read *Madame Bovary*; Jane read *Jane Eyre*.

The single-pair reading (40a) is easy to derive. In (41), atomic drefs x and y are introduced, and the operator $\textbf{Ans}_{u,\nu}$ checks whether they are unique.

(41)



$① = \lambda g.\left\{g^{\substack{u\mapsto x\\ \nu\mapsto y}} | \text{GL}(x), \text{BK}(y), \text{RD}(x,y)\right\}$ (drefs x and y are atomic here.)

Single-pair reading: $\textbf{Ans}_{u,\nu}$ = $\lambda m.\lambda g.m(g)$ if $|\{g(u) \mid g \in m(g)\}| = 1$ and $|\{g(\nu) \mid g \in m(g)\}| = 1$.

$② = \lambda g.\{g^{\substack{u\mapsto x\\ \nu\mapsto y}} | x = \iota x[\text{GL}(x) \wedge \text{RD}(x,y)], y = \iota y[\text{BK}(y) \wedge \text{RD}(x,y)]\}$

(**Anna**$_u$, ***AK***$_\nu$ bring more tests on drefs.)

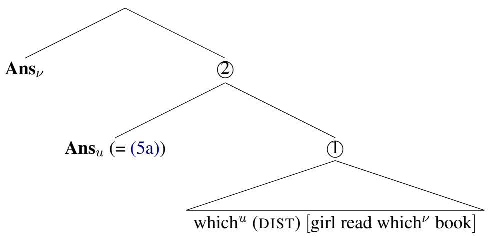
For the pair-list reading (40b), its short answer can be considered a function written as a set of ordered pairs: i.e., $f = \{\langle \text{A}, \textit{AK}\rangle, \langle \text{E}, \textit{MB}\rangle, \langle \text{J}, \textit{JE}\rangle\}$ (see Schlenker 2006; Brasoveanu 2011; Bumford 2015). Another observation is that pair-list reading is different from single-pair reading in supporting cross-sentential anaphora (see (42) vs. (43)).

(42) Which^u girl read which$^\nu$ book? Does she$_u$ like it$_\nu$? ✓ single-pair; # pair-list

(43) Which^u girl read which$^\nu$ book? Do they$_u$ like their$_u$ book / # it$_\nu$? ✓ pair-list

Thus the pair-list reading of (40) amounts to 'what is the function f s.t. for each girl x' who read, $f(x')$ is all the books x' read and $|f(x')| = 1$'. In (44), *which*^{u} *girl* introduces a (potentially plural) dref x, and *which*$^\nu$ (*book*) introduces a functional dref f, mapping each atomic x' to the book-sum x' read. I assume that a hidden distributivity operator DIST is responsible for the singularity of *girl*. **Ans**$_u$ selects out the maximal sum of girl-readers. **Ans**$_\nu$ checks the singularity of *book*, i.e., whether for each x', $|f(x')| = 1$. If so, f is the short answer.

(44)



$① = \lambda g.\{g^{\substack{u\mapsto x\\ \nu\mapsto f}} | \text{G}(x), \forall x'_{\text{ATM}} \sqsubseteq x[f(x') = \Sigma f(x')[\text{BK}(f(x')) \wedge \text{RD}(x', f(x'))]]\}$

$\textbf{Ans}_\nu = \lambda m.\lambda g.m(g)$ if $\forall x'[x'_{\text{ATM}} \sqsubseteq g(u) \rightarrow |g(\nu)(x')| = 1$

4 Comparison with recent works

Among recent works, there are heated discussions on how to represent the drefs introduced by *wh*-items, how to have access to short answers, etc. These issues motivate new approaches to questions, incorporating insights from dynamic semantics or categorial approaches (e.g., Krifka 2001; Xiang 2021; Li 2019, 2021; Dotlačil and Roelofsen 2019, 2021). The current work joins this trend of research and has a similar empirical coverage, including the access to short answers, deriving *wh*-conditionals, supporting cross-sentential anaphora, generating pair-list reading for multi-*wh*-questions, etc.[5]

Compared to other recent works, the current work is distinguished in at least two aspects. First, conceptually, it provides a new perspective on answerhood, teasing apart the analytically invariant, definite part and the part that contributes new information. New information is considered tests at another layer, providing further description for the analytically invariant part. Thus even though a *wh*-question might be answered with different informative short answers in different possible worlds, the analytical definite dref remains stable. Consequently, in analyzing question phenomena, we can just start with this complete true answer, and various phenomena address what/how additional information is related to this analytical answer.

Second, empirically, the current approach brings a more unified treatment for *wh*-questions raised on different domains (e.g., entities, scalar values like degrees or intervals). Specific implementation of definiteness tests is based on the same idea of maximizing informativeness. We never need to loop over possible answers in the domain of *wh*-items, which is difficult for domains of non-entities.

5 Summary

This paper explores a post-suppositional view on *wh*-questions and answers. I analyze *wh*-items along with items like modified numerals: their semantic contribution all involves dref introduction and definiteness tests. Based on this, for answer to *wh*-questions, we can separate the invariant, analytical part, and the new information part. The new information part further serves as tests on the invariant part. This papers also sketches out how a series of related phenomena are analyzed. Further development and refinement is left for future work.

[5] The current work also provides an account for intervention effects (see e.g., Beck 2006), which is not included here.

References

Sigrid Beck. 2006. Intervention effects follow from focus interpretation. *Natural Language Semantics*, 14(1):1–56.

Adrian Brasoveanu. 2011. Sentence-internal different as quantifier-internal anaphora. *Linguistics and philosophy*, pages 93–168.

Adrian Brasoveanu. 2013. Modified numerals as post-suppositions. *Journal of Semantics*, 30(2):155–209.

Dylan Bumford. 2015. Incremental quantification and the dynamics of pair-list phenomena. *Semantics and Pragmatics*, 8 (9):1–70.

Dylan Bumford. 2017. Split-scope definites: Relative superlatives and Haddock descriptions. *Linguistics and Philosophy*, 40(6):549–593.

Ivano Caponigro. 2003. *Free not to ask: On the semantics of free relatives and wh-words cross-linguistically*. Ph.D. thesis, UCLA.

Ivano Caponigro. 2004. The semantic contribution of *wh*-words and type shifts: Evidence from free relatives crosslinguistically. In *Semantics and linguistic theory*, volume 14, pages 38–55.

Gennaro Chierchia and Ivano Caponigro. 2013. Questions on questions and free relatives. In *Sinn und Bedeutung*, volume 18.

Ileana Comorovski. 2013. *Interrogative phrases and the syntax-semantics interface*, volume 59. Springer Science & Business Media.

Veneeta Dayal. 1996. *Locality in WH quantification: Questions and relative clauses in Hindi*. Springer Science & Business Media.

Veneeta Dayal. 2016. *Questions*, volume 4. Oxford University Press.

Veneeta Srivastav Dayal. 1994. Scope marking as indirect *wh*-dependency. *Natural language semantics*, 2(2):137–170.

Jakub Dotlačil and Floris Roelofsen. 2019. Dynamic inquisitive semantics: Anaphora and questions. In *Proceedings of sinn und bedeutung*, volume 23 (1), pages 365–382.

Jakub Dotlačil and Floris Roelofsen. 2021. A dynamic semantics of single-*wh* and multiple-*wh* questions. In *Semantics and Linguistic Theory*, volume 30, pages 376–395.

Jeroen Groenendijk and Martin Stokhof. 1982. Semantic analysis of *wh*-complements. *Linguistics and philosophy*, pages 175–233.

Jeroen Groenendijk and Martin Stokhof. 1984. On the semantics of questions and the pragmatics of answers. In *Varieties of Formal Semantics: Proceedings of the Fourth Amsterdam Colloquium*, pages 143–170.

Jeroen Groenendijk and Martin Stokhof. 1990. Partitioning logical space. Annotated handout for *ESSLLI* 2, Leuven.

Charles L Hamblin. 1973. Questions in montague grammar. *Foundations of Language*, 10:41–53.

Roland Hausser and Dietmar Zaefferer. 1978. Questions and answers in a context-dependent montague grammar. In *Formal semantics and pragmatics for natural languages*, pages 339–358. Springer.

Pauline Jacobson. 2016. The short answer: Implications for direct compositionality (and vice versa). *Language*, 92 (2):331–375.

Lauri Karttunen. 1977. Syntax and semantics of questions. *Linguistics and philosophy*, 1:3–44.

Manfred Krifka. 2001. For a structured meaning account of questions and answers. In *Audiatur Vox Sapientia. A Festschrift for Arnim von Stechow*, volume 52, pages 287–319.

Haoze Li. 2019. Deriving short answers from hamblin sets: A case study of mandarin wh-conditionals. In *Semantics and linguistic theory*, volume 29, pages 138–159.

Haoze Li. 2021. Mandarin wh-conditionals: A dynamic question approach. *Natural Language Semantics*, 29(3):401–451.

Mingming Liu. 2017. *Varieties of alternatives: Focus particles and wh-expressions in Mandarin*. Berlin and Beijing: Springer and Peking University.

Lance Edward Nathan. 2006. *On the interpretation of concealed questions*. Ph.D. thesis, MIT.

Bertrand Russell. 1905. On denoting. *Mind*, 14(56):479–493.

Philippe Schlenker. 2006. Scopal independence: A note on branching and wide scope readings of indefinites and disjunctions. *Journal of Semantics*, 23(3):281–314.

Roger Schwarzchild and Karina Wilkinson. 2002. Quantifiers in comparatives: A semantics of degree based on intervals. *Natural language semantics*, 10:1–41.

Yimei Xiang. 2021. A hybrid categorial approach to question composition. *Linguistics and Philosophy*, 44(3):587–647.

Linmin Zhang. 2023. Cumulative reading, QUD, and maximal informativeness. To appear in the *Proceedings of LENLS 19*.

Linmin Zhang and Jia Ling. 2021. The semantics of comparatives: A difference-based approach. *Journal of Semantics*, 38(2):249–303.