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. Inspired by Brasoveanu (2013); Charlow (2017); Bumford (2017), I propose a unified treatment of items like modified numerals, focus items, and *wh*-items: they (i) introduce a discourse referent (dref) in a non-deterministic way and (ii) impose definiteness tests (and additional tests) in a delayed, post-suppositional manner at the sentential / discourse level. Thus, with a question like *who smiled*, the (maximally informative) dref 'the one(s) who smiled' is derived. A short answer like '*Mary and Max*' is considered another post-supposition-like, delayed test, checking whether the dref 'the one(s) who smiled' is identical to (or includes) 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 perspective on the semantics of *wh*-questions and (short) answers within a dynamic semantics framework.

In this introduction, I present the conceptual and technical motivations behind this project.

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.

This observation is reminiscent of existing literature on **post-suppositional** phenomena, i.e., delayed tests that (i) check definiteness or (ii) provide additional information about something definite.

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

(2) Exactly 3^u boys saw exactly 5^ν movies.
Cumulative reading of (2):
$$\underbrace{\sigma x \sigma y[\text{BOY}(x) \wedge \text{MOVIE}(y) \wedge \text{SEE}(x, y)]}_{\text{the mereologically maximal } x \text{ and } y \text{ satisfying these restrictions}}$$
$$\wedge \underbrace{|y| = 5 \wedge |x| = 3}_{\text{cardinality tests}}$$
(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:

First, modified numerals introduce, in a non-deterministic way, (potentially plural) discourse referents (drefs), x and y (assigned to u and ν respectively).

Second, 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. Specifically, (i) 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; (ii) these mereologically maximal drefs are finally checked for their cardinality.

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

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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).

Conceptually, cumulative-reading sentences and *wh*-questions are parallel in at least two aspects, which motivate a similar underlying analysis:

1. **Relativized definiteness**: The meaning of cumulative-reading sentence (2) is about all the boys who saw movies and all the movies seen by boys, not all the boys or all the movies in context. For *wh*-question (1), evidently, the sentence is about all those who smiled, not all people in context. In both cases, definiteness is relativized by information beyond the immediate DP.

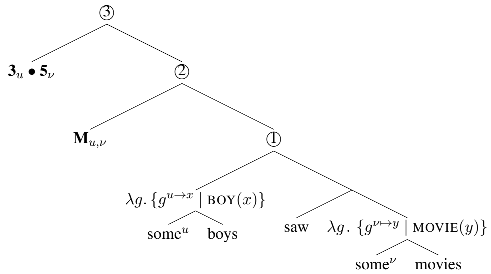
2. **Additional information about relativized definite items**: Cardinalities in sentence (2) bring additional information about the boys who saw movies and the movies seen by boys. The good short answer in (1b) also provides additional information with regard to all those who smiled. The lack of this kind of additional information would often result in triviality and thus degradedness (see (1a) and (3)).

(3) ??The boys saw the movies.
Intended: 'The boys who saw movies saw the movies seen by boys.'

Under the analysis of (2) by Brasoveanu (2013), relativized definiteness is realized via a global application of maximality operators. Essentially, the derivation starts with non-deterministic alternatives. Then, crucially, definiteness tests are not applied immediately at the local DP level, but as post-suppositions, delayed to a higher, sentential level, resulting in relativized definiteness. Thus a pseudo-wide-scope effect in interpreting modified numerals is achieved, via splitting their semantic contribution into an indefinite part and a definite part.

Technically, the spirit of this post-suppositional (or split) analysis of Brasoveanu (2013) can be realized in different ways: e.g., higher-order dynamic generalized quantifiers, update semantics, post-suppositions (see Charlow 2017 for a detailed discussion and comparison). To facilitate presentation, here I adopt the dynamic semantics formalism of Bumford (2017), which is based on the non-deterministic state monad developed by Charlow (2014). A re-engineering of (2) is shown in (4).

(4) Exactly 3^u boys saw exactly 5^ν movies.



①: Introducing drefs and restrictions:
$① = [\![\text{some}^u \text{ boys saw some}^\nu \text{ movies}]\!] =$
$\lambda g\,.\left\{g^{u\mapsto x}_{\nu\mapsto y} \mid \text{MOVIE}(y), \text{BOY}(x), \text{SAW}(x,y)\right\}$

②: Applying maximality tests:
$② = \mathbf{M}_{u,\nu}(①) =$
$\lambda g\,.\{g^{u\mapsto x}_{\nu\mapsto y} \mid x = \Sigma x[\text{BOY}(x) \wedge \text{SEE}(x,y)],$
$y = \Sigma y[\text{MOVIE}(y) \wedge \text{SAW}(x,y)]\}$

③: Checking cardinalities:
$③ = \mathbf{3}_u \bullet \mathbf{5}_\nu(②)$
$= ②$, if $|x| = 3$ and $|y| = 5$

(5) **Mereology-based maximality test:**
$\mathbf{M}_u \overset{\text{def}}{=} \lambda m.\lambda g\,.$
$\{h \in m(g) \mid \neg\exists h' \in m(g)\,.\,h(u) \sqsubset h'(u)\}$

(6) **Cardinality test:**
$\mathbf{3}_u \overset{\text{def}}{=} \lambda m.\lambda g\,.\,m(g), \text{if } |g(u)| = 3$
(if not, this returns $\emptyset$)

Within this framework, as illustrated in (2), meaning derivation is 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. 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.

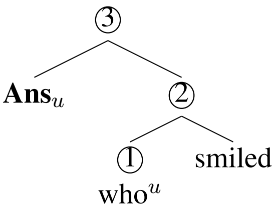
In (4), drefs are first introduced and various restrictions are added onto them (see ①). Maximality operators (see (5)) pick out the mereologically maximal drefs satisfying the restrictions (see ②). Finally, cardinality tests (see (6)) check the cardinalities of the maximal drefs (see ③). The cumulative-reading of (2) is true if the derivation does not return an empty set.

The rest of the paper is organized as follows. Section 2 presents the main proposal with this 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

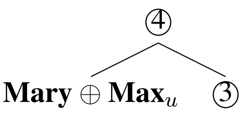
(7) and (8) illustrate the core idea of the current proposal with a dynamic semantics implementation à la Bumford (2017).

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



①: Introducing drefs:
① $= [\![\text{who}^u]\!] = [\![\text{some}^u \text{ (people)}]\!]$
$= \lambda g\,.\,\{g^{u\mapsto x} |\ \text{HUMAN}(x)\}$
②: More restrictions are added:
② $= [\![\text{who}^u \text{ smiled}]\!]$
$= [\![\text{some}^u \text{ (people) smiled}]\!]$
$= \lambda g\,.\,\{g^{u\mapsto x} |\ \text{HMN}(x) \wedge \text{SML}(x)\}$
③: Applying maximality tests:
③ $=$ **Ans**$_u$(②) $=$
$\lambda g\,.\,\{g^{u\mapsto x} |\ x = \Sigma x[\text{HMN}(x) \wedge \text{SML}(x)]\}$

(8) Mary and Max **short answer to (7)**



④: Checking additional information
④ $=$ **Mary** $\oplus$ **Max**$_u$(③) $=$
$\lambda g\,.\,\{g^{u\mapsto x} |\ x = \Sigma x[\text{HMN}(x) \wedge \text{SML}(x)]\}$,
if $x =$ **Mary**$\oplus$**Max** (or $x \sqsupseteq$ **Mary**$\oplus$**Max**)

(9) **Maximality test** (informativeness-based):
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: **Ans**$_u \overset{\text{def}}{=} \lambda m.\lambda g\,.\,\{h \in m(g) \mid \neg\exists h' \in m(g)\,.\,h(u) \sqsubset h'(u)\}$

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

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

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

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

In (7), *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 HUMAN(x) here (see ① in (7)).

After other relevant restrictions are added (here SMILE(x), see ② in (7)), an operator **Ans**$_u$ is applied to ② (see (9) and ③ in (7)), picking out the definite dref that eventually leads to the maximally informative true answer to the *wh*-question.

Obviously, in this specific example (7), where the domain of the *wh*-item is a set of individuals and the predicate *smile* is inherently distributive, **Ans**$_u$ amounts to picking out the mereologically maximal dref, as shown in (9a). Essentially, ② means 'someone that smiled (smiled)', and ③ means 'the one(s) who smiled (smiled)'. In some sense, the question meaning (i.e., here ③ in (7)) is equivalent to the meaning of its analytical answer – ③.

(8) illustrates how a good short answer works. As defined in (10), **Mary** $\oplus$ **Max**$_u$ plays the same role as cardinality tests do in a cumulative-reading sentence (see (6) and (4)). If **Mary** $\oplus$ **Max**$_u$ is a complete 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 (11) (see e.g., Comorovski 2013).

(11) a. Someone^u laughed. They$_u$ are noisy.
b. Who^u laughed? They$_u$ are noisy.

(12) a. $\lambda g\,.\,\{g^{u\mapsto x} |\ x = \Sigma x[\text{HMN}(x) \wedge \text{LG}(x)]\}$
b. $\lambda g\,.\,\{g^{u\mapsto x} |\ \text{NOISY}(x)\}$

The analysis of the first and second sentence in discourse (11b) is sketched in (12). The parallelism between *wh*-items and indefinites are immediately explained: both introduce drefs that support cross-sentential anaphora. The only difference is that a *wh*-item also involves (relativized) definiteness.

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 (13)).

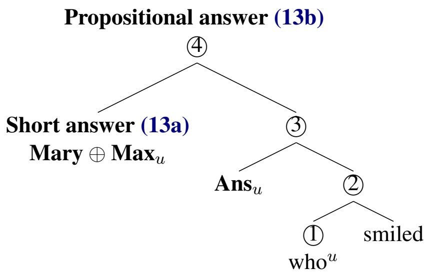
(13) **Categorial approach**:
$[\![\text{who smiled}]\!] = \lambda x.\textsc{smile}(x)$

a. **Short answer**: Mary and Max

b. **Propositional answer**:
$[\text{Mary and Max}]_F$ smiled.

Similar to the categorial approach, the current analysis also composes a short answer with question meaning to derive the meaning of the corresponding propositional answer. As shown in (14), when the short answer **Mary** $\oplus$ **Max**$_u$ (see (10)) is applied to the question meaning (see ③ in (7)), the meaning of the propositional answer (13b) is naturally derived (see also ④ in (8)).

(14)



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 a short answers should not contain hidden, elided linguistic materials that would be part of a corresponding propositional answer. Actually Jacobson (2016) points out that for a *wh*-question like (7), a short answer like (8) is a genuine **answer** that addresses the *wh*-question, while a corresponding propositional answer is a derived **reply**. What a genuine answer really is is actually also reflected by the focus of a propositional answer.

The current analysis for short answers is in line with Jacobson (2016). A short answer as analyzed in (10) does not contain any ellipsis, and it only indicates (i) which dref in the *wh*-question the information **Mary** $\oplus$ **Max**$_u$ is connected with and (ii) whether this connection is an identity relation or a part-whole relation. Sometimes the distinction between a complete and a potentially partial short answer can be reflected by intonation.

There are two major differences between the current analysis and the categorial approach. First, the current analysis addresses the definiteness in interpreting a *wh*-question. Second, under the current analysis, a good short answer actually behaves as if it takes a pseudo-wide-scope over the *wh*-question.

The current analysis also 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 Section 2.1).

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 (7).

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 (9)) is applicable to something like ② in (7), 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 (15) seem to support Hamblin (1973)'s view (see Dayal 2016), because according to our intuition, for (15), the interpretation of *where is Mary* seems 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).

(15) 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 (16), *wh*-free-relatives can be replaced by a definite DP, and (16a) and (16b) have the same truth condition. The analysis in (17) explains this truth-conditional equivalence. In (17), $\mathbf{Ans}_u$ plays the same role as a mereological maximality operator, leading to the maximal sum of things cooked by Adam (see (9a)).

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

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

A further issue is about mention-some questions.

(18) Who^u can help her?

(19) Mary was looking for who^u can help her.
= Mary was looking for someone^u that can help her.
≠ Mary was looking for all the^u people that can help her.

As illustrated in (18) and (19), in these examples, there is also a parallelism between mention-some *wh*-questions (see (18)) and mentions-some *wh*-free-relatives (see (19)). However, it seems that mereological maximality is not involved.

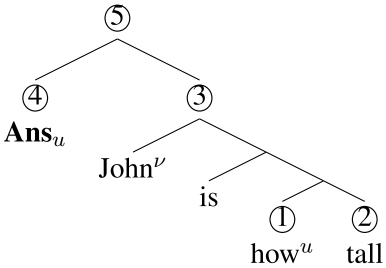
Actually, in (9), I consider $\mathbf{Ans}_u$ a maximality operator that leads to the most informative answer. Maximal informativeness is not necessarily based on mereological maximality (see Zhang 2023a).

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 (9a). 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.

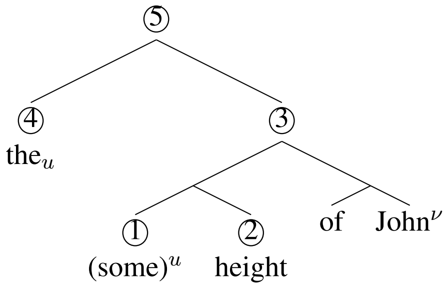
2.5 The parallelism between *wh*-questions and concealed questions

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 (20) and (21), the content of what Mary knows is expressed as a *wh*-question in (20) and as a concealed question in (21). (22) shows their parallel derivation.

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



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



(22) 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 $= \lambda g.\ \left\{g^{\substack{u\mapsto I\\ \nu\mapsto x}}|\textsc{height}(x) \subseteq I, x = \text{J}\right\}$
④ $= \mathbf{Ans}_u \overset{\text{def}}{=} \lambda m.\lambda g.$
$\{h \in m(g)\ |\ \neg\exists h' \in m(g).\, h'(u) \subset h(u)\}$
⑤
$= \mathbf{Ans}_u(\lambda g.\ \left\{g^{\substack{u\mapsto I\\ \nu\mapsto x}}|\textsc{ht}(x) \subseteq I, x = \text{J}\right\})$
$= \lambda g.\ \left\{g^{\substack{u\mapsto I\\ \nu\mapsto x}}|\ I = \iota I[\textsc{ht}(\text{J}) \subseteq I], x = \text{J}\right\}$

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, lead-

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

ing 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 **Ans**$_u$ (see ④ in (22)) 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 (23).

Under the weak exhaustive reading, (23) means that Mary has the complete knowledge about all walkers (see (23a)). Under the strong exhaustive reading, (23) means that Mary has the complete knowledge about everyone in the domain, including all walkers and non-walkers (see (23b)).

(23) 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 (24), the embedded *wh*-question in (23) 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 postsuppositional test, providing additional information on $g(u)$. This part is similar to a good short question (e.g., (1b)) in that their semantic contribution is based on and added to some definite item already established and restricted by the *wh*-question.

For the weak exhaustive reading, as shown in (25), **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 (26), **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 (25) and (26), $\mathfrak{Know}_{\mathfrak{M}}$ is of type $\langle tt \rangle$, a set of items of type t.

(24) $[\![(23)]\!] =$
  Mary knows$_u$(**Ans**$_u$($[\![$who^u walks$]\!]$))
  Ans$_u$($[\![$who^u walks$]\!]$) $=$
  $\lambda g.\ \{g^{u \mapsto x} |\ x = \Sigma x[\textsc{hmn}(x) \wedge \textsc{walk}(x)]\}$

(25) **Weak exhaustivity reading**:
  Mary knows$_{\text{weak } u}$ $\stackrel{\text{def}}{=}$ $\lambda m.\lambda g.m(g)$ 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.)

(26) **Strong exhaustivity reading**:
  Mary knows$_{\text{strong } u}$ $\stackrel{\text{def}}{=}$ $\lambda m.\lambda g.m(g)$ if $\forall x'[x' \sqsubseteq g(u) \rightarrow \mathfrak{Know}_{\mathfrak{M}}(x' \sqsubseteq g(u))] \wedge \forall x'[x' \not\sqsubseteq g(u) \rightarrow \mathfrak{Know}_{\mathfrak{M}}(x' \not\sqsubseteq g(u))]$
  (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 (27) and (28). In (28), 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.

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

(28) **Mary knows**$_{\text{part } u}$ $\stackrel{\text{def}}{=}$ $\lambda m.\lambda g.m(g)$ 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 (24)). What varies is what is included in Mary's knowledge. The current analysis also reflects the extensionality of knowledge: What is 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 (23) 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

[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).

question coordination. For a sentence like (29), the traditional approach predicts that it has the same meaning as *Jenny knows who voted for Andy and Bill* (see (30)), and this prediction is inconsistent with our intuitive interpretation for (29).

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

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

Under the current analysis, for (29), 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 (31)). Finally, (32) shows that Jenny has the (weak) exhaustive knowledge about these two maximal drefs. In her knowledge, each dref is tracked separately.

(31) $\mathbf{Ans}_{u_1}([\![\text{who}^{u_1} \text{ voted for Andy}]\!])$
$\wedge \mathbf{Ans}_{u_2}([\![\text{who}^{u_2} \text{ voted for Bill}]\!])$
$= \lambda g.\{g^{u_1 \mapsto x}_{u_2 \mapsto y} \mid x = \Sigma x[\text{HMN}(x) \wedge \text{VT}(x, \text{A})], y = \Sigma y[\text{HMN}(y) \wedge \text{VT}(y, \text{B})]\}$

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

3.3 *Wh*-conditionals

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

(33) Who^u comes depends on who$^\nu$ is invited.

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

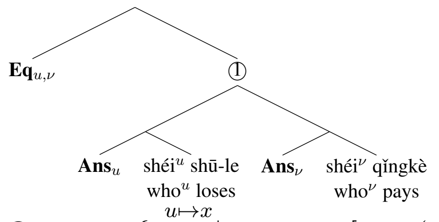
Sentence (33) addresses the correlation between the answers to two *wh*-questions. The answer to the question *who^u comes* correlates with or depends on the answer to the question *who$^\nu$ is invited*. As proposed in (34), $\textbf{depend-on}_{u,\nu}$ works as a postsuppositional test, checking whether there is a function f mapping the maximal dref assigned to ν, i.e., $g(v)$, to the maximal dref assigned to u, i.e., $g(u)$. Thus again $\textbf{depend-on}_{u,\nu}$ is like a short answer or *Mary knows* in that their semantic contribution is based on and added to existing definite items.

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 (35) 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 (36) and (37), this intuitive reading is naturally accounted for.

(35) 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)

(36)



① $= \lambda g.\{g^{u \mapsto x}_{\nu \mapsto y} \mid x = \Sigma x[\text{HMN}(x) \wedge \text{LOSE}(x)], y = \Sigma y[\text{HMN}(y) \wedge \text{PAY}(y)]\}$

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

More general cases of *wh*-conditionals, including those involving degree questions, can also be accounted for. (38) 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.

(38) 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)

(39) $\lambda g.\{g^{u_1 \mapsto x, \nu_1 \mapsto I_1}_{u_2 \mapsto y, \nu_2 \mapsto I_2} \mid x = \Sigma x[\text{FD}(x)], y = \Sigma y[\text{MN}(y)], I_1 = \text{AM}(x), I_2 = \text{AM}(y)\}$

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

For (38), 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). (39) 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.e., I_1 and I_2. Obviously, I_1 and I_2 are the most informative answers to the two *wh*-questions in (38). Similar to (34), silent operator $\textbf{determine}_{\nu_1,\nu_2}$ works as a test, checking whether there is a context relevant function f that maps $g(\nu_1)$ to $g(\nu_2)$. The operator $\mathbf{Eq}_{u,\nu}$ (37) can be considered a special case of the operator $\textbf{determine}_{\nu_1,\nu_2}$ in (40).

3.4 Question dependency

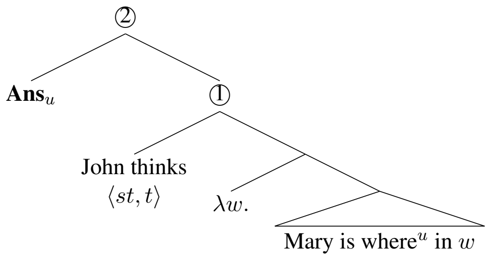
Syntactically, there are two subtypes of question dependency: **direct dependency** (see (41)) and **indirect dependency** (see (42)). Semantically, they have the same meaning. Based on their syntactic differences, Dayal (1994, 2016) advocate distinct analyses to derive their meaning. Here I follow this desideratum to address question dependency.

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

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

As shown in (43), the derivation of direct dependency is straightforward. *Wh*-item *where*^{u} introduces a dref (which is a location), and the application of the definiteness test **Ans**$_u$ is delayed until the matrix sentence level. Due to the selection requirement of *think*, roughly speaking, the embedded question should be something of type $\langle st\rangle$, and ⟦John thinks⟧ is of type $\langle st, t\rangle$, restricting items of type $\langle st\rangle$. Eventually, (41) denotes the most informative dref x such that John thinks Mary is in x. Obviously, this dref x does not necessarily satisfy the restriction '$\text{IN}(\text{Mary}, x, w)$' (in which w is a free variable). Thus the intensionality of attitude-reporting predicate *think* is captured.

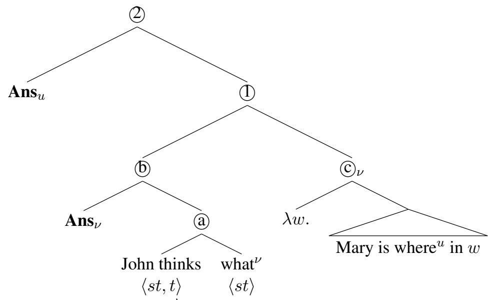
(43)



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

Then as shown in (44), for (42), 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, (42) also denotes the most informative dref x such that John thinks Mary is in x, i.e., the same meaning as (41).

(44)



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

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 relativized definite items that constitute complete true answers. In (44), **Ans**$_u$ is not applied on ⓒ, but delayed until discourse level. 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.,

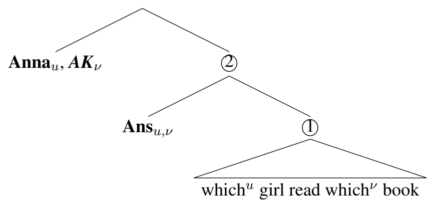
(45) Which girl read which book?

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 (45a) is easy to derive. In (46), atomic drefs x and y are introduced, and the operator **Ans**$_{u,\nu}$ checks whether they are unique.

(46)



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

(drefs x and y are atomic here.)
Single-pair reading: $\mathbf{Ans}_{u,\nu} = \lambda m.\lambda g.m(g)$ if $|\{g(u) \mid g \in m(g)\}| = 1$ and $|\{g(\nu) \mid g \in m(g)\}| = 1$.
(i.e., there is a unique girl-reader and a unique book read by a girl.)
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.)

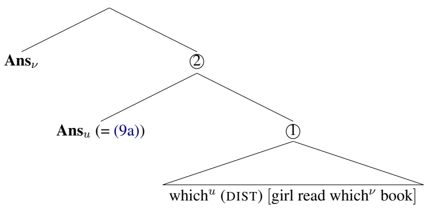
For the pair-list reading (45b), its short answer can be considered a function written as a set of ordered pairs: i.e., $f = \{\langle \text{A}, \textit{AK}\rangle, \langle \text{E}, \textit{MB}\rangle, \langle \text{J}, \textit{JE}\rangle\}$ (see Schlenker 2006; Brasoveanu 2011; Bumford 2015). Another observation is that pair-list reading is different from single-pair reading in supporting cross-sentential anaphora (see (47) vs. (48)).

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

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

Thus the pair-list reading of (45) 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 (49), *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.[5]

(49)



① $= \lambda g.\{g^{\substack{u \mapsto x \\ \nu \mapsto f}} | \text{G}(x), \forall x'_{\text{ATM}} \sqsubseteq x[f(x') = \Sigma f(x')[\text{BK}(f(x')) \wedge \text{RD}(x', f(x'))]]\}$
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.[6]

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 answers 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.

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[5]For a question like *which girl smiled*, based on how it supports cross-sentential anaphora (see (47) vs. (48)), I assume that only an analysis like (46), but not like (49), is possible.

[6]In addition to the phenomena discussed in this paper, the current perspective on *wh*-questions also provides an account for focus intervention effects (see Zhang 2023b).

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