

Mandarin *wh*-conditionals: A question + dynamic meaning approach

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Abstract

In Mandarin, two *wh*-clauses can be embedded in a conditional, forming a special construction widely known as a ‘*wh*-conditional’. *Wh*-conditionals are of interest to linguists because the *wh*-expressions in a *wh*-conditional must co-refer. How to make sense the fusion of a conditional and *wh*-clauses as well as the co-reference relation has been a long standing issue. Two competing approaches have been advanced to shed light on *wh*-conditionals: the indefinite approach (Cheng & Huang 1996; Chierchia 2000; a.o.), which treats *wh*-expressions as indefinites that exhibit dynamic potentials, and the question + categorial meaning approach (Xiang 2016, 2020a; Liu 2016, 2017), which treats *wh*-clauses as questions denoting functions of various types (or categories). Both approaches face nontrivial challenges but at the same time also have unique advantages. The goal of this paper is to devise an alternative approach that borrows insights from these two approaches but do away with their shortcomings. On one hand, the proposed analysis treats *wh*-clauses as questions. On the other hand, it recognizes the dynamic potential of interrogative *wh*-expressions, i.e., their ability to introduce discourse referents. A *wh*-conditional is analyzed as quantification over the values of these discourse referents, which creates the impression of co-reference of the *wh*-expressions involved (via unselective binding). To the extent that the present analysis is on the right track, it extends the application of the dynamic potential of *wh*-expressions beyond anaphora.

Keywords *Wh*-conditionals · Conditionals · Dynamic semantics · Hamblin Semantics · Discourse referents

1 Introduction

Generally speaking, *wh*-expressions are not used as anaphors. For example, (1) does not mean “Ann knows who arrived late and they left early”. In other words, the people who arrived late are not obligatorily identical to the ones who left early.

- (1) Ann knows *who* arrived late and *who* left early.

Interestingly, two instances of a *wh*-expression are *required* to co-refer in Mandarin when they appear in a conditional.¹ Such a sentence, illustrated in (2), is called a ‘*wh*-conditional’.

¹ It has been noticed in the literature (Lin 1999; Hua 2000; Liu 2016) that, in a *wh*-conditional, if the *wh*-expressions involve different NP complements, like *which kid* and *which father*, they do not co-refer but functionally related. I will turn to this kind of *wh*-conditionals in Section 3.

(2) is taken to be a conditional not only because of its meaning, but also because it contains a conditional marker *jiù*, which is obligatory in ordinary conditional sentences, as in (3).²

- (2) Shéi shū-le, shéi 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.’
- (3) Nǐ shū-le, nǐ *(jiù) qǐngkè.
 you lose-ASP you then pay
 ‘If you lose the bet, you’ll pay.’

An intriguing question is why two *wh*-expressions, which generally cannot co-refer, must co-refer in a *wh*-conditional, as indicated by the translation of (2).

The classical approach to *wh*-conditionals, first proposed in Cheng & Huang (1996) and further developed in Lin (1996, 1999), Tsai (1999), Chierchia (2000), Pan & Jiang (2015), etc., analyzes *wh*-expressions as indefinites. They exploit the dynamic properties of indefinites, i.e., their ability to introduce discourse referents (drefs, for short), to achieve co-reference of *wh*-expressions in *wh*-conditionals. Following Karttunen (1976), drefs are represented as an infinite list of semantic objects that are potential antecedents for anaphora. In particular, the dynamic properties enable *wh*-expressions to act like variables, which are bound by an adverbial quantifier or modal contributed by the conditional structure as proposed in the Lewis (1975)–Kratzer (1981)–Heim (1982) (LKH) approach to conditionals. When there is no overt adverbial quantifier or modal, it is assumed that a conditional involves a covert necessity modal **NEC**, which gives rise to universal quantification.³ Based on this approach, the meaning of the *wh*-conditional in (2) can be represented as (4). R is an accessibility relation between possible worlds given in the context.

$$(4) \quad \mathbf{NEC}_{x,w} [\text{lose}_w(x)] : (\text{pay}_w(x)) = \lambda w' \forall x, w. (w \in R(w') \wedge \text{lose}_w(x)) \rightarrow \text{pay}_{w'}(x)$$

Both *wh*-expressions contribute the same variables and are bound by the same quantifica-

² The counterparts of *if* in Mandarin can occur in *wh*-conditionals (Lin 1996; Pan & Jiang 2015), as in (i) and (ii). These data further support that *wh*-conditionals are morphologically built on conditionals.

- (i) Shéi yàoshì shū-le, shéi jiù qǐngkè.
 who if lose-ASP who then pay
 ‘For every person x , if x is the one losing the bet, x is the one paying.’
- (ii) Xiāngshān méiyǒu liǎngpiàn xiāngtóng de hóngyè. Rúgǎo shéi zhǎodào le, shéi jiù shì zuì
 Xiangshan not-have two same DE maple-leave if who find perf who then be most
 xìngfú de rén.
 happy de person
 ‘There are no two maple leaves in Xiangshan that are exactly the same. For every x if x is the person who finds them, x is the happiest person.’ (Pan & Jiang 2015)

However, according to Cheng & Huang (1996), the occurrence of *rúgǎo* and *yàoshì* is more restrictive in *wh*-conditionals than in ordinary conditionals. The distribution of these *if*-particles is not the main issue of this paper, and hence I will not include these particles in the data of *wh*-conditionals.

³ Chierchia (1992, 2000) proposes that a conditional lacking an adverbial quantifier or a modal involves a covert *always*, which quantifies over situations. This paper does not tackle the issue whether a covert *always* or a covert necessity modal is involved in a conditional. Given that *wh*-conditionals often express regularities/rules that go beyond the actual world, as pointed out by a reviewer, I simply follow Kratzer (1981) and Cheng & Huang (1996) and assume that a covert necessity modal is involved.

tional operator, so they must co-refer. As such, the meaning of *wh*-conditionals is based on the standard semantics of conditionals.

However, it is observed that the *wh*-expressions in *wh*-conditionals have distributional patterns closer to their interrogative uses than to their indefinite uses. Based on this, Xiang (2016, 2020a) and Liu (2016, 2017) have argued that the *wh*-expressions embedded in a *wh*-conditional are in their interrogative uses rather than non-interrogative indefinites.⁴ On this view, a *wh*-conditional is treated as a type of conditional connecting two question-denoting clauses. This move raises a new question: how are question meaning and conditional meaning fused together to give rise to co-reference in a *wh*-conditional?

In order to address this question, Xiang and Liu both move away from the widely used propositional approach to question meaning, such as Hamblin–Karttunen semantics and partition semantics, and adopt the categorial approach (Hausser & Zaefferer 1979), which treats questions as sets of possible *short* answers. On their view, a *wh*-conditional expresses a dependency between the short answers to the questions involved. For concreteness, the meaning of the *wh*-conditional in (2) can be paraphrased as (5).⁵

- (5) For all worlds *w*, the short answer to the question *who loses* in *w* is also the short answer to the question *who pays* in *w*. \rightsquigarrow For all worlds *w*, the person who loses in *w* is the one who pays in *w*.

However, their account suffers from compositional issues not found in the indefinite approach. These issues are inherited from the categorial treatment of question meaning and are amplified in *wh*-conditionals.⁶ Given these problems, the issue of how to derive the co-reference of *wh*-expressions in a *wh*-conditional via combining question meaning and conditional meaning essentially remains unresolved.

The key to resolving this issue, I argue, lies in an important property of interrogative *wh*-expressions overlooked by previous studies in the question-based approach—the dynamic potential of these expressions. As demonstrated in (6), the interrogative *shéi* ‘who’ sup-

⁴ Following Karttunen (1977), Liu and Xiang both assume that a *wh*-expression lexically denote an existential quantifier. However, the denotation is shifted in some way when they derive a question meaning.

⁵ Strictly speaking, the meaning paraphrased in (5) is not a conditional interpretation in the sense of the LKH approach. Crucially, the *wh*-antecedent clause is not taken to restrict the domain of possible worlds. As a consequence, a potential problem may arise in a *wh*-conditional with an overt adverb. For example, the *wh*-conditional in (i) is true in such a case: given ten situations where a person wins, only in two situations the winner pays (Cheng & Huang 1996). It shows that the quantification given by *hěnnshǎojiàn* ‘seldom’ only cares about situations in which a person wins rather than all situations.

(i) Hěnnshǎojiàn, shéi yíng-le, shèi qǐngkè.
seldom who win-ASP who pay
‘For few situations *s* such that *x* wins in *s*, *x* pays in *s*.’

If the quantificational domain were not restricted, (i) could be true in such a scenario: suppose we have 100 situations in total and only in ten of them there is a person who wins, the winner pays in *all* the ten situations. Intuitively, the scenario falsifies (i). Nevertheless, the problem is not very serious. The most direct solution is to assume that the information expressed by the *wh*-antecedent clause can be accommodated into the domain of the adverb (see also Dayal’s (1997) discussion on the quantificational variability of *ever*-free relatives).

⁶ In the literature there is a ‘correlative/free relative’ approach to *wh*-conditionals. In this approach, *wh*-conditionals are taken to be correlatives or *ever* free relatives (Bruening & Tran 2006; Luo & Crain 2011; Huang 2010b). Cheng & Huang (1996) and Liu (2016) have pointed out problems with this view, so I will not review this approach in this paper.

ports cross-sentential anaphora (Comorovski 1996; van Rooy 1998; Aloni & van Rooy 2002; Haida 2007; Murray 2010; Dotlačil & Roelofsen 2018; a.o.), which has been standardly used to diagnose dref introduction since Karttunen (1976).⁷ Intuitively, *shéi* introduces alternative people as drefs. It could be Alex, Bob or Carl. The pronoun in the subsequent question is anaphoric to the drefs, i.e., the value of the pronoun co-varies with the drefs. To facilitate the discussion, I introduce the terminology ‘*wh-drefs*’, which refers to drefs introduced by *wh*-expressions.

- (6) Shéi¹ shū-le? Wǒmēn yào tā₁ qǐngkè ma?
 who lose-ASP we ask him pay SFP
 ‘Who lost the bet? Should we ask him to pay the bill?’

Once the dynamic potential of interrogative *wh*-expressions is recognized, it is easy to see how the question approach can be remedied with ingredients from the indefinite approach. In fact, the core of the indefinite approach is precisely the dynamicness of *wh*-expressions, i.e., their ability to introduce drefs, rather than their indefiniteness. This fact is most clearly shown in Chierchia’s (2000) implementation. Since interrogative *wh*-expressions share with indefinites the ability to introduce drefs, it is entirely possible to devise an account that brings together the question approach and the dynamic essence of the indefinite approach. I call such an account a ‘question + dynamic meaning’ approach. Since the dynamic essence can replace the categorial treatment of questions, the resulting account does not run into compositional issues found in the question + categorial meaning approach.

The question + dynamic meaning approach advanced in this paper involves the development of the dynamicization of Hamblin Semantics (Hamblin 1973; Kratzer & Shimoyama 2002; Shimoyama 2006).⁸ Briefly speaking, a *wh*-expression denotes **a set of dynamic individuals**, each of which introduces an entity as a dref, and correspondingly, a *wh*-question denotes **a set of dynamic propositions**, each of which is associated with a dref introduced by the relevant *wh*-expression. The meaning of a *wh*-question characterizes possible propositional answers, which involve *wh*-drefs, as in (7). The alternatives evoked by *who* are set in SMALL CAP and they each introduce as a dref an entity set in sans serif.

- (7) who loses $\xrightarrow{\text{possible answers}}$ Answer in w_1 : ANN loses $\xrightarrow{\text{wh-dref}}$ ann
 Answer in w_2 : BOB loses $\xrightarrow{\text{wh-dref}}$ bob
 Answer in w_3 : CLEO loses $\xrightarrow{\text{wh-dref}}$ cleo

In a dynamic setting, drefs are retrievable. Informally, the values associated with drefs can be ‘picked out’ from dynamic propositions. In (7), the entities ann, bob and cleo can be picked out and collected into a set, which is characterized by the function in (8), i.e., a predicate meaning. The variable x just ranges over all the entities in the domain of *who*. In this sense, the interrogative *wh*-expression is ‘replaced’ with a variable, ready to be bound.

⁷ In this paper, a linguistic expression introducing a dref is superscripted with an index, while the anaphor referring to the dref is subscripted with the same index.

⁸ In principle, any question semantics can be dynamicized. I have chosen to work with Hamblin Semantics just because most studies on the semantics of Mandarin questions (Dong 2009, 2018; He 2011; Li & Law 2016) follow Hamblin Semantics. They have argued that the composition mechanism assumed in Hamblin Semantics can handle a wider range of phenomena.

$$(8) \quad \lambda x \lambda w. \left[\begin{array}{l} x \text{ is introduced as a dref by } who \text{ and} \\ \text{the answer to } who \text{ loses in } w \text{ is } [x \text{ loses}] \end{array} \right]$$

Formally, I show in Section 4.3 that the set of dynamic propositions denoted by *who loses* can be mapped to the function in (8). This mapping is nothing novel: it is just a composition of Dayal’s (1996) answerhood operator and Dekker’s (1993) Existential Disclosure.

With the transformation shown in (8), a conditional is able to connect two *wh*-clauses denoting sets of dynamic propositions (question meaning). Take (2) as an example. Both the antecedent *wh*-clause and the consequent *wh*-clause are transformed into the functions characterizing sets of entities introduced as *wh*-drefs. The functions can be mapped to the restrictor and the scope of the covert necessity modal involved in the conditional. So, the meaning of (2) can be rendered as (9).

$$(9) \quad \text{NEC}_{x,w} \left\{ \begin{array}{l} \text{Restrictor} \left[\begin{array}{l} x \text{ is introduced as a dref by the 1st } who \text{ and} \\ \text{the answer to } who \text{ loses in } w \text{ is } [x \text{ loses}] \end{array} \right] \\ \text{Scope} \left[\begin{array}{l} x \text{ is introduced as a dref by the 2nd } who \text{ and} \\ \text{the answer to } who \text{ pays in } w \text{ is } [x \text{ pays}] \end{array} \right] \end{array} \right\}$$

= For every accessible world w and entity x s.t. x is the one who loses in w , then x is the one who pays in w

Given (9), both *wh*-expressions introduce drefs independently, but the variable x bound by **NEC** is associated with the *wh*-drefs. As a result, the *wh*-conditional is verified by the model in which the person who loses a bet always pays.

The combination of *wh*-clauses and conditionals proposed here is close to Chierchia’s (2000) proposal. Chierchia analyzes *wh*-clauses as existential statements and uses Existential Disclosure to wipe out existential force, transforming a propositional meaning to a predicate meaning. Although the transformation route in my analysis (from *sets of propositional meanings* to predicate meanings) is not the same as Chierchia’s, it also generates predicates. Consequently, the transformed *wh*-clauses can combine with a conditional operator in the same way as Chierchia uses.

This paper is organized as follows. Section 2 presents two sets of empirical phenomena. The first set motivates the assumption that a *wh*-conditional embeds two *wh*-clauses with question denotations, while the second set challenges the ‘question + categorial meaning’ approach. Section 3 shows that *wh*-expressions in *wh*-conditionals have dynamic potentials, calling for a dynamic treatment of *wh*-conditionals. Section 4 demonstrates how Hamblin Semantics is dynamicized and proposes a mechanism that retrieves the values of *wh*-drefs. With the retrieving mechanism at hand, Section 5 analyzes *wh*-conditionals as quantification over entities introduced as *wh*-drefs. In addition to the basic cases, the analysis can also explain the phenomena described in Section 2. Section 6 shows that the present analysis predicts other properties of *wh*-conditionals, involving a maximality inference, focus intervention effects and pair-list readings. Section 7 points out remaining issues for future research. Section 8 concludes. A formal fragment and derivations for the core data can be found in Appendix.

2 Data

This section presents several empirical phenomena that are used to argue that neither the indefinite approach nor the question + categorial meaning approach are adequate for *wh*-conditionals. For the indefinite approach, identifying *wh*-expressions as indefinites is not supported empirically. For the question + categorial meaning approach, although assuming that *wh*-conditionals embed *wh*-questions has a lot of empirical advantages, couching the analysis in the categorial approach to *wh*-questions invites new empirical problems.

2.1 *Wh*-expressions in *wh*-conditionals are more like interrogative ones

In Cheng & Huang's (1996) classical analysis, *wh*-conditionals are analogous to donkey sentences. The *wh*-expressions in a *wh*-conditional are analyzed as indefinites and act like variables. So, they can be bound by the quantificational operator involved in a conditional, as reviewed in the introduction section. In this section, I provide two phenomena that challenge the empirical foundation of the approach and show that the *wh*-expressions in a *wh*-conditional share hallmark properties with interrogative ones.⁹

2.1.1 Certain *wh*-expressions lack indefinite uses but can still form *wh*-conditionals

An important empirical basis for the indefinite approach is that *wh*-expressions in Mandarin can be interpreted as indefinites when occurring in downward-entailing contexts (Cheng 1991; Li 1992; Lin 1998). As in (10), *shěnmē* 'what' is embedded in the antecedent of the conditional and receives an indefinite interpretation. Therefore, it's reasonable to assume that *wh*-expressions embedded in *wh*-conditionals are also indefinites.

- (10) Rǔgǔo Lǐbái mǎi-le shěnmē, tā yídìng huì lái gào sù wǒ.
if Libai buy-ASP what he must will come tell me
'If Libai bought something, he surely would come to tell me.'

Nevertheless, not all *wh*-expressions have indefinite uses when they are embedded in the antecedent clause of a conditional (Tsai 1994; Lin 1996). The reason *wh*-expression *wèishěnmē* 'why', the manner *wh*-expression *zěnmē* 'how' and a series of degree *wh*-expressions, like *dūoshǎo* 'how many', *dūodà* 'how big', *dūokuài* 'how fast', etc., do not have an indefinite use, as shown from (11) through (13).¹⁰

- (11) *Rǔgǔo Lǐbái wèishěnmē bèi jiěgù, tā yídìng huì lái gào sù wǒ.
if Libai why BEI fire he must will come tell me
Intended 'If Libai was fired for some reason, he surely would come to tell me.'
- (12) *Rǔgǔo Lǐbái zěnmē xiūhǎo-le chē, tā yídìng huì hěn gāoxìng.
if Libai how fix-ASP car he must will very happy

⁹ Liu (2016) and Xiang (2020a) argue for a question-based analysis based on different sets of empirical data. However, Huang (2018) revises the indefinite approach and replies to their challenges. In this paper, I will not recapitulate the relevant empirical points.

¹⁰ It should be noted that degree *wh*-expressions can be interpreted as an indefinite in the scope of the negation marker *méi* 'not'. However, its indefinite use is very limited. Except for *méi*, other indefinite use licensors like conditionals, polar questions and modals cannot license the indefinite use of these *wh*-expressions.

Intended ‘If Libai fixed the car in some way, he must be very happy.’

- (13) *Rǔgǔo Lǐbài diū-le dūoshǎo dōngxī, tā yídìng huì lái gào sù wǒ.
if Libai lose-ASP how.many thing he must will come tell me
Intended ‘If Libai lost some number of items, he surely would come to tell me.’

However, these *wh*-expressions may form *wh*-conditionals, as exemplified in the following examples (Tsai 1994; Lin 1996).¹¹

- (14) Lǐbái wèishěnmē bèi jiěgù, Dùfǔ jiù wèishěnmē bèi jiěgù.
Libai why BEI fire Dufu then why BEI fire
‘For every *x*, if *x* is the reason why L was fired, *x* is the reason why D was fired.’
- (15) Lǐbái zěnmē xiū chē, Dùfǔ jiù zěnmē xiū chē.
Libai how fix car Dufu then how fix car
‘For every *x*, if *x* is the way that L fix cars, *x* is the way that D fix cars.’
- (16) Lǐbái chī-le dūoshǎo, Dùfǔ jiù chī-le dūoshǎo.
Libai eat-ASP how.many Dufu then eat-ASP how.many
‘For every *x*, if *x* is the amount of the food that L ate, *x* is the amount of the food that D ate.’

The well-formedness of these examples casts doubt on the indefinite approach: if the meaning of *wh*-conditionals is built on the semantics of indefinites, why can *wh*-expressions that lack indefinite uses still give rise to *wh*-conditionals? By contrast, it’s not surprising if the *wh*-clauses in (14) and (16) are considered questions. *Wèishěnmē* and *dūoshǎo* are question words alongside many other *wh*-expressions.¹²

¹¹ In Mandarin, *wèishěnmē* is ambiguous between a ‘why’ reading and a ‘for what’ reading. The latter is not a real *wh*-adverb and can be analyzed as a preposition phrase. In order to avoid this ambiguity, I use the passive construction in (14). According to Tsai (2008), *wèishěnmē* with the ‘for what’ reading is about the purpose of the agent and hence cannot be used in a passive sentence.

¹² Almost all *wh*-expressions can be used in *wh*-conditionals (Cheng & Huang 1996; Liu 2016), but the reason *zěnmē* ‘how come’ and the sentence initial *wèishěnmē* ‘why’ cannot (Huang 2018), as exemplified below.

- (i) a. *Tā zěnmē chídào, wǒ jiù zěnmē chídào.
he how.come late I then how.come late
b. *Wèishěnmē tā chídào, wèishěnmē wǒ jiù chídào.
why he late why I then late
Intended ‘For every *x*, if *x* is the reason why he was late, *x* is the reason why I was late.’

I suggest that the ungrammaticality of these examples be due to the high syntactic position of the relevant *wh*-expressions. Tsai (2008) has convincingly argued that *zěnmē* and the sentence initial *wèishěnmē* occupy a position in the left periphery of a sentence. However, the antecedent clause and the consequent clause of a *wh*-conditional may not have a full left periphery, because the topic expressions are not allowed in both clauses, as evidenced by (ii).

- (ii) *[Zhè-piān wénzhāng, shéi dú-guò], [zhè-piān wénzhāng, shéi jiù lái jiǎng].
this-CL paper who read-ASP this-CL paper who then come present
Intended ‘For every *x*, if *x* is the person who has read this paper, *x* is the person who presents it.’

Consequently, the *wh*-clauses embedded in a *wh*-conditional may not have a syntactic position to locate the reason *zěnmē* and the sentence initial *wèishěnmē*.

2.1.2 Association with focus sensitive particles

Mandarin *wh*-expressions have both interrogative and indefinite uses, but they can be focused only when used interrogatively (Chao 1968; Dong 2018; Yang 2018). This observation is also confirmed cross-linguistically (Haida 2007; AnderBois 2012; a.o.). A piece of evidence is that a focus sensitive particle, like *zhǐ* ‘only’ or *shì* (a marker for cleft sentences), can be associated with an interrogative *wh*-expression, (Aoun & Li 1993; Shi 1994; Li & Law 2016), as shown in (17), but not with an indefinite *wh*-expression, as shown in (18).

- (17) a. Zhècì **shì** shéi shū-le?
this.time SHI who lose-ASP
‘Who is it that lost the bet this time?’
b. Lǐbái **zhǐ** gěi shéi sòng-le lǐwù?
Libai only to who send-ASP gift
‘Who is the person such that Libai only sent her gifts?’
- (18) a. *Rúguǒ zhècì **shì** shéi shū-le, tā jiù yào qǐngkè.
if this.time SHI who lose-ASP he then must pay
b. *Rúguǒ Lǐbái **zhǐ** gěi shéi sòng-le lǐwù, nǐ jiù lái gào sù wǒ.
if Libai only to who send-ASP gift you then come tell me

In *wh*-conditionals, *wh*-expressions can associate with focus sensitive particles (see also Cheung 2007), as in (19) and (20). This indicates that the *wh*-expressions in a *wh*-conditional behave pattern like interrogative *wh*-expressions, rather than indefinite ones.

- (19) Zhècì **shì** shéi shū-le, wǒmen jiù ràng shéi qǐngkè.
this.time SHI who lose-ASP we then ask who pay
‘For every person *x*, if it is *x* who loses, *x* is the one who we will ask to pay.’
- (20) Qùnián tā **zhǐ** gěi shéi sòng-le lǐwù, jīnnián wǒ jiù **zhǐ** gěi shéi sòng lǐwù.
last.year he only to who send-ASP gift this.year I then only to who send gift
‘For every *x*, if *x* is the only person that he sent a gifts to last year, *x* is the only person that I will send a gift to this year.’

If the *wh*-clauses embedded in a *wh*-conditional are considered questions, the association between focus sensitive particles and *wh*-expressions is expected.

2.2 Moving to a question-based approach: challenges and goals

From what have been shown, the *wh*-expressions in a *wh*-conditional exhibit the properties of interrogative *wh*-expressions, instead of existential *wh*-expressions. The most direct way of capturing the observation is to analyze a *wh*-conditional as a conditional connecting two *wh*-questions. Nevertheless, such a question-based analysis would not be considered fully successful until the following research questions are addressed:

- (21) a. How does a conditional connect two *wh*-questions compositionally?
b. Can the question-based analysis explain the co-reference of *wh*-expressions?

Xiang (2016, 2020a) and Liu (2016, 2017) tackle these two problems on the basis of a cat-

egorical treatment of short answers to *wh*-questions. They propose that a *wh*-conditional embeds two *wh*-questions and expresses a dependency between the short answers to the *wh*-questions. The meaning of (22), according to this approach, can be rendered as (23-a). Because the short answer to a *wh*-question is the object that resolves the issue raised by the question, (23-a) is equivalent to (23-b).

- (22) Shéi shū-le, shéi 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.’
- (23) a. For all accessible worlds w , the short answer to *who loses the bet* in w is also the short answer to *who will pay* in w .
 b. For all accessible worlds w , the person who loses the bet in w is the one who pays in w .

In the literature, short answers are traditionally derived using the categorial approach to questions (Hausser & Zaefferer 1979; von Stechow & Zimmerman 1984; Ginzburg & Sag 2000; Jacobson 2016; Sharvit & Kang 2016; Xiang 2020a; a.o.). Specifically, the meaning of a *wh*-question is modeled as a function mapping various objects to propositions. For example, the questions *who lost the bet* and *who will pay* denote the functions in (24-a) and (24-b), respectively. Both functions characterize sets of possible short answers to the corresponding question.

- (24) a. $\llbracket \text{who lost the bet} \rrbracket^{w_0} = \lambda x \lambda w. \text{human}_{w_0}(x) \wedge \text{lose.bet}_w(x)$
 b. $\llbracket \text{who will pay} \rrbracket^{w_0} = \lambda x \lambda w. \text{human}_{w_0}(x) \wedge \text{pay}_w(x)$

Given a world w , the short answers to these questions in w are individuals who loses the bet in w and the ones who pays in w . With the short answers in hand, the representation in (23) can be derived.¹³

Moreover, Zimmermann (1985) and Groenendijk & Stokhof (1989) have argued that among three major static theories of question meaning (the categorial approach, the Hamblin approach (Hamblin 1973) and the partition approach (Groenendijk & Stokhof 1984)) only the categorial approach is capable of deriving short answers semantically. Hence, if we want to pursue a short answer analysis of *wh*-conditionals, the categorial approach seems to be the go-to choice. When formalizing their proposals, Xiang’s and Liu’s analyses both assume that the question meaning involves a component that represents a functional meaning as we see in (24-a) and (24-b).¹⁴

Although the categorial approach indeed offers a sound solution for the two questions

¹³ Both Xiang (2016, 2020a) and Liu (2016, 2017) syncategorematically assign meaning postulates to *wh*-conditionals, rather than categorically derive the meaning of *wh*-conditionals based on that of ordinary conditionals. This kind of treatments does not illustrate the connection between these two types of conditionals.

¹⁴ The structured meaning approach to questions (von Stechow 1991) is also exploited to derive short answers in the literature (Krifka 2001a; Weir 2018) and Liu’s (2016) formal analysis is just built on a variant of the structured meaning approach. However, the derivation of short answers in the structured meaning approach is not essentially different from that in the categorial approach. In particular, the structured meaning of a question is modeled as a pair containing a set of entities and a function, which also plays an essential role in deriving short answers. As a result, all the challenges to the categorial approach that are presented in the following subsections also apply to the structured meaning approach.

in (21), this approach has its own limits (Groenendijk & Stokhof 1989; George 2011). The limitations are in turn inherited by the question + categorial meaning approach to *wh*-conditionals. The following subsections just discuss three empirical phenomena that are not fully covered by the question + categorial meaning approach.

2.2.1 *Wh*-conditionals can embed conjunctions of *wh*-clauses

The fact that a *wh*-conditional can embed two conjunctions of *wh*-clauses is rarely singled out in the literature, because it is not beyond the expectation for the classical indefinite approach. However, it challenges the question-based approach, for there is a difficulty deriving short answers to conjunctions of *wh*-questions. Consider (25) and (26), which embed conjunction(s) of *wh*-clauses. Note that in Mandarin clausal conjunction is not marked by an overt conjunct. In addition, the second *wh*-conjunct in (26) has a null object, which can be understood as a null pronoun *pro* referring to *shěnmē*.¹⁵

- (25) Nǐ [chī **shěnmē** cài], tā [hē **shěnmē** jiǔ], wǒ jiù yào [chī **shěnmē** cài], [hē
you eat what dish he drink what wine I then must eat what dish drink
shěnmē jiǔ].
what wine
‘For every dish *x* and every wine *y*, if *x* is what you eat and *y* is what he drinks, *x* is
what I want to eat and *y* is what I want to eat and drink’
- (26) [Nǎ-gè nánhái qūe **shěnmē**], [nǎ-gè nǚhái zhènghào yòu yǒu *pro*],
which-CL boy lack what which-CL girl happen you have it
nǎ-gè nánhái jiù huì gēn **nǎ-gè** nǚhái jiè **shěnmē**.
which-CL boy then will with which-CL girl borrow what
‘For every boy *x*, every thing *y* and every girl *z*, if *x* lacks *y* and *z* happens to have
it, *x* will borrow *y* from *z*.’

According to the question-based approach, (25) and (26) indicate the identity of the short answers to *wh*-questions in the antecedent clauses and the consequent clauses. In (25), the conjunction of *wh*-clauses should admit a dish–wine pair as its short answer, whereas in (26), the short answer to the *wh*-antecedent clause should be a triple consisting of a boy, a thing and a girl. However, it has not been adequately addressed how these short answers are derived in semantics.

It has been a long standing problem for the categorial approach to handle conjunction of *wh*-clauses (Groenendijk & Stokhof 1989; Krifka 2001a; Xiang 2020a; a.o.). The main issue is that two *wh*-clauses may have different non-propositional types and hence should not be conjoinable. The non-propositional question meaning assumed in the categorial approach can always be shifted to a propositional one. Based on this formal property, many studies pursuing the categorial approach have proposed various ways to shift the categorial meanings of *wh*-clauses to the corresponding propositional meanings (Groenendijk & Stokhof 1984, 1989; Berman 1991). Let me take Berman’s (1991, p226) proposal for concreteness. Following him, we define an operator π mapping an function *R*, which may have

¹⁵ Note that *pro* is bound by *shěnmē* but not in the syntactic scope of the latter. Therefore, this binding relation is a **dynamic** one. It calls for a dynamic semantics of *wh*-expressions. I will return to this issue in Section 3.

a sequence of arguments, to a set of propositions, as in (27).

$$(27) \quad \pi(R) := \lambda p \exists x_1, \dots, x_n. p = R(x_n) \dots (x_1)$$

Before two *wh*-clauses are conjoined, π applies to each of them, yielding two sets of propositions. They can be conjoined via a pointwise conjunction rule, defined as in (28).

$$(28) \quad \llbracket Q_1 \text{ and } Q_2 \rrbracket = \{ p \wedge q \mid p \in \llbracket Q_1 \rrbracket, q \in \llbracket Q_2 \rrbracket \}$$

However, this view fails to explain *wh*-conditionals. Although the π -application resolves the problem of coordination, it eliminates an important advantage of the categorial approach: once the functional meaning denoted by a *wh*-question is shifted to a set of propositions, it is not possible to track possible short answers to the *wh*-question anymore, as argued in Zimmermann (1985) and Groenendijk & Stokhof (1989). As a consequence, if we employ π to derive the conjunctions of *wh*-clauses in (25) and (26), we are no longer able to get the short answers to the relevant questions.¹⁶

The other solution to the conjunction issue in the categorial approach is to conjoin two lifted questions (Krifka 2001a; Xiang 2020a). Specifically, question meanings can be lifted to functions to propositions, as discussed in Groenendijk & Stokhof (1989). In (25), the conjunction of *wh*-clauses embedded in the antecedent clause is analyzed as follows. In the categorial approach, both *wh*-clauses denote predicates of type $e \rightarrow s \rightarrow t$. Therefore, \mathcal{Q} is a function of type $(e \rightarrow s \rightarrow t) \rightarrow (s \rightarrow t)$, the type for generalized quantifiers. The denotation in (29) models a set of generalized quantifiers, not dish–wine pairs. Hence, it does not generate possible short answers to the conjunction of *wh*-clauses.

$$(29) \quad \lambda x \lambda w. \underbrace{\text{dish}_{w_0}(x) \wedge \text{eat}_w(x)(\llbracket \text{you} \rrbracket)}_{\lambda x \lambda w. \text{dish}_{w_0}(x) \wedge \text{eat}_w(x)(\llbracket \text{you} \rrbracket)} \wedge \underbrace{\mathcal{Q}(\llbracket \text{he drank what wine} \rrbracket^{w_0})}_{\lambda x \lambda w. \text{wine}_{w_0}(x) \wedge \text{drink}(x)(\llbracket \text{he} \rrbracket)}$$

Additionally, the lifting analysis enables conjunctions of *wh*-clauses to take scope. Therefore, some might consider resolving the problem raised in (25) by scoping both conjunctions of *wh*-clauses above the conditional embedding them.¹⁷ In particular, the meaning of (25) can be derived as follows.

$$(30) \quad (Q_1 = \text{'you ate what dish'}, Q_2 = \text{'he drank what wine'}, Q_3 = \text{'I ate what dish'}, Q_4 = \text{'I drank what wine'})$$

$$\begin{aligned} & [\lambda \mathcal{Q}. \mathcal{Q}(\llbracket Q_1 \rrbracket) \wedge \mathcal{Q}(\llbracket Q_2 \rrbracket)] \lambda P. [\lambda \mathcal{Q}. \mathcal{Q}(\llbracket Q_3 \rrbracket) \wedge \mathcal{Q}(\llbracket Q_4 \rrbracket)] \lambda P'. \llbracket \text{jiù} \rrbracket(P')(P) \\ &= [\lambda \mathcal{Q}. \mathcal{Q}(\llbracket Q_1 \rrbracket) \wedge \mathcal{Q}(\llbracket Q_2 \rrbracket)] \lambda P. \llbracket \text{jiù} \rrbracket(\llbracket Q_3 \rrbracket)(P) \wedge \llbracket \text{jiù} \rrbracket(\llbracket Q_4 \rrbracket)(P) \\ &= \llbracket \text{jiù} \rrbracket(\llbracket Q_3 \rrbracket)(\llbracket Q_1 \rrbracket) \wedge \llbracket \text{jiù} \rrbracket(\llbracket Q_4 \rrbracket)(\llbracket Q_1 \rrbracket) \wedge \llbracket \text{jiù} \rrbracket(\llbracket Q_3 \rrbracket)(\llbracket Q_2 \rrbracket) \wedge \llbracket \text{jiù} \rrbracket(\llbracket Q_4 \rrbracket)(\llbracket Q_2 \rrbracket) \end{aligned}$$

As a result, we get a conjunction of four *wh*-conditionals. In each *wh*-conditional, no conjunction of *wh*-clauses is embedded. Accordingly, the resulting reading is equivalent to

¹⁶ Jacobson (2016) suggests that *wh*-questions should be coordinated at the speech act level, as proposed by Krifka (2001b), but it's not clear if short answers are still retrievable when *wh*-questions are packaged into speech acts.

¹⁷ In Krifka (2001a) and Xiang (2020a), embedded conjunctions of questions take *obligatory* wide scope relative to question-embedding predicates.

(31).¹⁸ However, this reading is not available for (25).

- (31) Nǐ chī **shěnmē** cài, wǒ jiù yào chī **shěnmē** cài; nǐ chī **shěnmē** cài, wǒ jiù
 you eat what dish I then want eat what dish you eat what dish I then
 yào hē **shěnmē** jiǔ; tā hē **shěnmē** jiǔ, wǒ jiù yào chī **shěnmē** cài; tā
 want drink what wine he drink what wine I then want eat what dish he
 hē **shěnmē** jiǔ, wǒ jiù yào hē **shěnmē** jiǔ.
 drink what wine I then want drink what wine
 ‘If you eat some kind of dish, I want to eat the same kind of dish; if you eat some
 kind of dish, I want to eat the same kind of wine; if he drinks some kind of wine, I
 eat the same kind of dish; and if he drinks some kind of wine, I want to drink the
 same kind of wine.’

Besides, Xiang (2020a) notices that the lifting analysis has another flaw: when the conjoined *wh*-clauses do not have the same type, the scope argument \mathcal{Q} yielded by lifting does not have a fixed type. For example, in (26), the conjoined *wh*-clauses in the antecedent clause denote functions of different types, as in (32).

- (32) a. $\llbracket \text{which boy lacks what} \rrbracket = \lambda x \lambda y \lambda w. \text{boy}_{w_0}(x) \wedge \text{thing}_{w_0}(x) \wedge \text{lack}_w(y)(x)$
 b. $\llbracket \text{which girl has pro} \rrbracket = \lambda z \lambda w. \text{girl}_{w_0}(z) \wedge \text{have}_w(\llbracket \text{pro} \rrbracket)(z)$

The two *wh*-clauses are lifted and conjoined, giving rise to $\lambda \mathcal{Q}. \mathcal{Q}' (\llbracket \text{which boy lacks what} \rrbracket) \wedge \mathcal{Q}'' (\llbracket \text{which girl has pro} \rrbracket)$. The scope arguments \mathcal{Q}' and \mathcal{Q}'' are of different types and consequently the abstracted variable \mathcal{Q} does not have a uniform type. This is not possible for a simple type theory.^{19,20}

2.2.2 Conditionals cannot embed A-not-A questions

Accounts of *wh*-conditionals couched in the question + categorial meaning approach is confronted with a potential over-generation problem. The central spirit of the accounts is that *wh*-conditionals express a question dependency with respect to short answers. *Yes-no* questions also admit short answers. In the categorial approach, the meaning of polar questions is normally modeled as a function from functions to propositions (Groenendijk & Stokhof

¹⁸ Note that the *wh*-expressions in (31) range over kinds, i.e., *shěnmē cài* means ‘what kind of dish’, while *shěnmē jiǔ* means ‘what kind of wine’. See Lin (1999) for a detailed discussion about the domain of *shěnmē*.

¹⁹ See Xiang (2020, ft34) for a potential solution to this issue.

²⁰ Although the existing analyses cannot generate correct short answers to conjunctions of *wh*-clauses, reformulating the categorial approach with Variable-free Semantics (Jacobson 1999) may resolve this problem, as pointed out by a reviewer. Briefly speaking, Variable-free Semantics assumes that a sentence with a free pronoun denotes a function to propositions. For example, *Ada ate it* denotes $\lambda x. \text{eat}(x)(a)$. In this sense, the meaning of a sentence with a pronoun in Variable-free Semantics may be the same as that of a *wh*-clause assumed in the categorial approach. In Variable-free Semantics, composing the meaning of the sentence *He bought it and She was happy* yields a function $\lambda x \lambda y \lambda z. \text{eat}(y)(z) \wedge \text{happy}(x)$. With the same mechanism, the conjunction of *wh*-clauses *who bought what and who was happy* is expected to denote the same function, which indeed characterizes a set of triples. This direction sounds promising, but still raises a potential issue that should be addressed. Specifically, in Variable-free Semantics, such an analysis may predict that *wh*-clauses could behave similarly to sentences with pronouns in other aspects of grammar, such as binding. That is, a *wh*-expression could be bound as a pronoun. This is an unwelcome prediction.

1984; Jacobson 2016; cf. Krifka 2001a), as exemplified in (33). The short answer to the polar question in (33) may be *yes* or *no*. *Yes* corresponds to the function $\lambda p.p$, whereas *no* the function $\lambda p.W - p$ (W is the set of all the possible worlds).

(33) $\llbracket \text{Did Ann cry} \rrbracket = \lambda f.f (\lambda w.\text{cry}_w(a))$

The question + categorial meaning approach does not have an obvious way to prevent the conditional marker *jiu* from connecting two polar questions. In Mandarin, polar questions can be marked by *A-not-A* forms and are often called ‘*A-not-A* questions’.²¹ The conditional in (34), which involves two polar questions in the *A-not-A* forms, is predicted to be allowed.

(34) *Lǐbái kū-méi-kū, Dùfǔ jiù kū-méi-kū.
Libai cry-not-cry Dufu then cry-not-cry

The predicted meaning of (34) would be that the short answer to the question *Libai cry-not-cry* is the same as the short answer to the question *Dufu cry-not-cry*, i.e., if Libai cried, then Dufu cried; and if Libai didn’t cry, then Dufu didn’t cry. However, *A-not-A* questions actually cannot be embedded in a conditional, as pointed out by Cheng & Huang (1996).

Note that the unacceptability of (34) does not mean that the *wh*-clauses in a *wh*-conditional cannot be construed as interrogative constructions. Even some question embedding verbs cannot embed all kinds of questions. For example, *surprise* is able to embed a *wh*-question but not a polar question (Karttunen 1977; Guerzoni 2007; Nicolae 2013; Romero 2015; Roelofsen et al. 2019). So, conditionals may behave like *surprise*: they can embed *wh*-questions but resist polar questions. An adequate question-based analysis should shed light on the embedding issue.²²

²¹ In Mandarin, polar questions can also be marked by the sentence final particle *mā*. This type of polar questions cannot be embedded in a conditional, either. However, the reason might not be semantic but syntactic. The particle *mā* is usually considered a force operator and occupies the highest functional head of a matrix question. As discussed in footnote 12, the clauses embedded in a conditional may not have a full left periphery. Hence, the particle *mā* is syntactically prevented from occurring in a conditional.

²² Alternative questions cannot be embedded in conditionals, either, as in (i). Alternative questions admit short answers that look similar to the ones to *wh*-questions. For example, the question ‘does Ada or Bob lose?’ can be answered by ‘Ada’. Given this, it’s surprising why they don’t give rise to conditionals similar to *wh*-conditionals.

(i) *Lǐbái háishì Dùfǔ chídào, Lǐbái háishì Dùfǔ jiù shòufá.
Libai HAISHI Dufu late, Libai HAISHI Dufu then be.penalized
Intended ‘No matter whether Libai or Dufu is late, he will be penalized.’

In fact, the analysis of alternative questions is debated. Biezma & Rawlins (2012), Erlewine (2014) and Li & Law (2016) analyze alternative questions in the same way as *wh*-questions, but Han & Romero (2002) and Huang (2010a) argue that alternative questions involve clausal coordination and ellipsis. Empirically, there are also dissimilarities between alternative questions and *wh*-questions. First, there are multiple-*wh* questions, but not multiple alternative questions (e.g., *did Ann or Bob eat apples or pears?* doesn’t have a pair-list answer like *Ann ate apples and Bob pears*). Second, universal quantifiers can quantify into *wh*-questions, leading to pair-list readings, but not into alternative questions. To my knowledge, these phenomena have not received a satisfactory account. Since how to analyze alternative questions is not deterministic, the argument built on alternative questions may not challenge or support an account for *wh*-conditionals. Based on this concern, this paper will not include an account for the unacceptability of (i) and leave it for future research.

2.3 Summary

The phenomena presented in this section leads to a dilemma. On one hand, *wh*-conditionals indeed share hallmark properties with questions and hence a question-based analysis is empirically motivated. On the other hand, the categorial approach to questions, which so far is the only way to embed questions in a conditional, is inadequate.

3 Dynamic potentials of *wh*-expressions

The dilemma shown in the last section can be resolved if we turn to a dynamic approach to the meaning of *wh*-clauses. The core of my proposal relies on the fact that *wh*-expressions have dynamic potentials: they can support cross-sentential anaphora, like indefinites (e.g. ‘A¹ boy was late. He₁ arrived at 10.’). Consider (35).

(35) [Which boy]¹ was late? When did he₁ arrive?

In order to answer the sequence of questions, the addressee must name the boy who was late and specify the time when he arrived. It shows that the pronoun co-varies with *which boy* even if the former is not in the syntactic scope of the latter. This is a typical instance of cross-sentential binding. From the perspective of dynamic semantics, this phenomenon indicates that *wh*-expressions are capable of introducing drefs, which can be retrieved by anaphoric expressions (Comorovski 1996; van Rooy 1998, Haida 2007, Murray 2010 and Dotlačil & Roelofsen 2018).

The same dynamic properties are also observed for *wh*-expressions in *wh*-conditionals. As illustrated by example (26) in Section 2.2.1, repeated in (36), the null pronoun *pro* co-varies with the *wh*-expression *shěnmē* in the separate clause.²³

(36) [Nǎ-gè nánhái qūe shěnmē¹], [nǎ-gè nǚhái zhènghào yòu yǒu pro₁],
which-CL boy lack what which-CL girl happen YOU have it
nǎ-gè nánhái jiù huì gēn nǎ-gè nǚhái jiè shěnmē.
which-CL boy then will with which-CL girl borrow what
‘For every boy *x*, every thing *y* and every girl *z*, if *x* lacks *y* and *z* happens to have it, *x* will borrow *y* from *z*.’

In addition, the *wh*-expressions in a *wh*-conditional can support ‘donkey’ anaphora. Conventionally, ‘donkey’ anaphora refers to the phenomenon that in a conditional a pronoun in the consequent clause is referentially dependent on an indefinite in the antecedent clause, such as ‘if a¹ farmer owns a² donkey, he₁ feeds it₂ very well’. For the *wh*-conditionals where the *wh*-expressions are co-indexed, it is not easy to form a *wh*-conditional with ‘donkey’ anaphora. This is because in a *wh*-conditional a *wh*-expression in the antecedent clause

²³ In this example, the first *wh*-clause contains multiple *wh*-expressions and may lead to a pair-list reading. The pair-list reading is compatible with such a situation: given a set of boys, each lacks a different thing and for each of these things there is a girl who has it. In this reading, the null pronoun is evaluated relative to the dependency consisting of different boy–thing pairs, i.e., for each boy, the null pronoun refers to the thing that he lacks, not the thing that all the boys lack. In Section 6.3.1, I will offer a formal analysis for multiple-*wh* clauses embedded in *wh*-conditionals. However, modeling reference to dependencies requires extra machinery not related to the main issue of the present paper. I reserve the discussion of this issue for another occasion.

is accompanied by a co-indexed *wh*-expression in the consequent clause. Consider (37). In this example, it cannot be teased apart whether the pronoun is bound by the second *shéi* or cross-sententially refers to the first *shéi*.

- (37) Shéi¹ yǎng-le māo, shéi¹ jiù yào gěi tā₁-de māo jiēzhòngyìmiáo.
 who keep-ASP cat who just must for her-DE cat vaccinate
 ‘For every person *x*, if *x* has a cat, *x* is the one who vaccinates his cat.’

Nevertheless, in some cases, a *wh*-expression in the antecedent clause of a *wh*-conditional may be *functionally* related to, rather than co-indexed with, the corresponding *wh*-expression in the consequent clause. A typical example is given in (38).

- (38) Nǎ-gè háizi chídào, nǎ-gè bàba jiù shòufá.
 which-CL kid late which-CL farther then penalized
 ‘For every kid *x*, if *x* is the kid being late, *x*’s dad is the dad being penalized.’

Departing from the *wh*-conditionals that we have discussed so far, the two *wh*-expressions do not range over the same domain of entities. As a result, the *wh*-expression in the antecedent refers to a child, but the one in the consequent the child’s father. Even though this kind of *wh*-conditionals does not involve co-referential *wh*-expressions, it is not allowed if the relevant *wh*-expressions are totally unrelated. (38) is well-formed only when the *wh*-expression in the consequent are functionally correlated with the one in the antecedent. That is, the *wh*-conditional cannot be true if a kid is late and another kid’s father is penalized. To my knowledge, Hua (2000) is the first to investigate such a phenomenon from a semantic perspective. Based on the indefinite approach, he assigns the following semantic representation to (38). The function *f* maps kids to their fathers.

- (39) $\text{NEC}_{x,w}[\text{kid}_w(x) \wedge \text{late}_w(x)]: (\text{father}_w(f(x)) \wedge \text{penl}_w(f(x)))$
 In prose: for every accessible world *w* and entity *x* s.t. *x* is a kid and *x* is late in *w*, *f*(*x*) is *x*’s father and *f*(*x*) is penalized in *w*

A fair question is where the functional dependency involved in a *wh*-conditional comes from. In (39), the functional dependency may be offered by the relational noun *father*, but in other cases, it is provided pragmatically. Suppose a couple went to a store, which is selling matching shirts for young couples, and the man said to his wife:²⁴

- (40) Nǐ mǎi nǎ-jiàn nüshì-de, wǒ jiù mǎi nǎ-jiàn nánshì-de.
 you buy which-ASP women’s I then buy which-CL men’s
 ‘For every women’s shirt *x*, if *x* is what you want to buy, the matched men’s shirt is what I will buy.’

(40) involves a functional relation between women’s shirts and men’s shirts, which is established in the context. So, it may be more plausible to assume that the functional dependency involved in a *wh*-conditional is contextually determined. When a relational noun is used, as

²⁴ (40) is modified from Liu’s (2016) example (56) on page 146.

in (38), the relevant functional relation becomes salient.^{25,26}

In a *wh*-conditional where *wh*-expressions are functionally related, the configuration of ‘donkey’ anaphora can be formed. For example, in (41) and (42), the pronouns in the consequent clauses clearly refer to the *wh*-expressions in the antecedent clauses.

- (41) Nǎ-gè¹ háizi fàn-le cuò, nǎ-gè² jiāzhǎng jiù huì pīpíng tā₁.
 which-CL kid make-ASP mistake which-CL parent then will scold him
 ‘For every kid *x*, if *x* makes a mistake, *x*’s parent is the one who will scold *x*.’
- (42) Nǎ-gè¹ háizi yǎng-le māo, nǎ-gè² jiāzhǎng jiù yào dài tā₁-de māo
 which-CL kid keep-ASP cat which-CL parent then must bring her-DE cat
 jiēzhòngyìmiáo.
 vaccinate
 ‘For every kid *x*, if *x* has a cat, *x*’parent is the one who brings *x*’s cat to vaccinate.’

In short, the dynamic potentials of *wh*-expressions motivate a dynamic treatment of these expressions, i.e., they introduce drefs. Drawing on the design that drefs are retrievable in dynamic semantics, I propose a new question-based analysis that models *wh*-conditionals as quantification over entities introduced as drefs by *wh*-expressions. This analysis combines merits from the indefinite approach and the question + categorial meaning approach, but also does away with their problems.

4 A dynamic semantics of *wh*-questions

Given the dynamic potentials of *wh*-expressions, this section develops a dynamic Hamblin semantics, which is a dynamicization of Hamblin Semantics of questions (Hamblin 1973; Kratzer & Shimoyama 2002; Shimoyama 2006). More importantly, it will be shown that a dynamic semantics for *wh*-questions has an additional merit—it supports the derivation of possible short answers from possible propositional answers via drefs.

Specifically, *wh*-expressions denote sets of dynamic individuals (i.e., dynamic generalized quantifiers), as in (43), each of which introduces a dref whose value is the corresponding static individual (i.e., an entity in the model), and *wh*-questions denote sets of dynamic sentence meanings, as in (44), which are possible propositional answers to the question.²⁷

$$(43) \quad \llbracket \text{which boy} \rrbracket_d = \{ \llbracket \text{ALEX} \rrbracket_d, \llbracket \text{BOB} \rrbracket_d, \dots \}$$

$$(44) \quad \llbracket \text{which boy was late} \rrbracket_d = \{ \llbracket \text{ALEX was late} \rrbracket_d, \llbracket \text{BOB was late} \rrbracket_d, \dots \}$$

Each propositional answer is associated with a dref introduced by *which boy*. These drefs

²⁵ The two ways of determining functional dependencies are close to Barker’s (1995) classification of possessives, i.e., lexical possessives and extrinsic possessives. A lexical possessive, like *John’s father*, has a possession relation encoded in the lexical meaning of the possessee, whereas an extrinsic possessive, like *John’s cat*, expresses a possession relation determined contextually.

²⁶ Section 7 will discuss a possibility of generalizing the functional relation to the *wh*-conditionals with co-indexed *wh*-expressions. Briefly, an ordinary *wh*-conditional might involve an identity function in the consequent clause. The identity function could help us understand the fact that the co-indexed *wh*-expressions in a *wh*-conditional must be morphologically identical.

²⁷ As $\llbracket \cdot \rrbracket$ maps a linguistic expression to a static meaning, $\llbracket \cdot \rrbracket_d$ maps a linguistic expression to a dynamic meaning.

are retrievable in dynamic semantics. Retrieving these drefs leads to possible short answers to this question, i.e., alex, bob, etc. The retrieving process in turn serves as the backbone of my analysis of *wh*-conditionals. In the remainder of this section, I spell out the various pieces needed to flesh out the ‘question + dynamic meaning’ approach to *wh*-conditionals.

4.1 Basic dynamics

In many dynamic setups, sentences denote relations over information states (info-states, for short). A sentence is true with respect to a model and an input info-state if it leads to at least one successful update. In this study, I follow Bittner (2014) and Murray (2010, 2014) and assume that an info-state is a pair of lists that store various drefs (cf. Dekker 1994). Specifically, a pair of lists consists of a top list and a bottom list, as shown below.²⁸

$$\left\langle \begin{array}{ccc} 0 & 1 & 2 \\ \boxed{a} & \boxed{b} & \boxed{c} \end{array}, \begin{array}{ccc} 0 & 1 & 2 \\ \boxed{e} & \boxed{h} & \boxed{g} \end{array} \right\rangle$$

top list bottom list

Such an info-state can model the information status of drefs. In this paper, I use the pairs of lists to distinguish two types of drefs:

1. A bottom list stores drefs introduced by expressions bearing the primary focus;
2. A top list stores drefs introduced by other expressions.

This assumption is compatible with Bittner (2014) and Murray (2010, 2014), who use the top lists to store drefs introduced by expressions serving as discourse topic. Generally, a topic does not bear the primary focus. Take the dialogue in (45) as an example. In B’s utterance, the subject *Ann* is the topic and the object *a book* that corresponds to *what* is usually taken to bear the primary focus. Consequently, the dref introduced by the subject is added to a top list, while the dref introduced by the object is added to a bottom list. The meaning of the sentence uttered by B is represented as (46).²⁹

(45) A: What about Ann? What did she buy?

B: [Ann]_T bought [a book]_F.

$$(46) \quad \llbracket (45) \rrbracket_d = \lambda w \lambda i \lambda j \exists x. \text{bk}_w(x) \wedge \text{buy}_w(x)(a) \wedge j = \langle \top_i \cdot a, \perp_i \cdot x \rangle$$

There are several relevant notations:

1. The sentence meaning is a dynamic proposition. Following Brasoveanu (2010), I model dynamic propositions as intensional relations between info-states.
2. *i* and *j* are variables over info-states (i.e. pairs of lists).

²⁸ Hardt (1999) proposes an alternative way to model the distinction of drefs. Info-states are represented as assignments and a discourse center is treated as a distinguished variable whose value can be reassigned. The analysis proposed in this paper can also be recast in Hardt’s formalism without any substantial change to the essence of the analysis. I use lists because the distinction of drefs is visually more explicit.

²⁹ The motivation for having two sub-lists independently comes from many cross-linguistic phenomena, including grammatical centering in Kalaallisut, reference to tense in English, null pronouns and aspect particles in Mandarin (Bittner 2014).

$$\begin{array}{c}
j : \left\langle \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & a \\ \hline \end{array}, \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & b_1 \\ \hline \end{array} \right\rangle \\
i : \left\langle \begin{array}{|c|} \hline 0 \\ \hline \dots \\ \hline \end{array}, \begin{array}{|c|} \hline 0 \\ \hline \dots \\ \hline \end{array} \right\rangle \rightsquigarrow \llbracket \text{Ann}_G \text{ bought a book} \rrbracket_d \rightsquigarrow j : \left\langle \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & a \\ \hline \end{array}, \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & b_2 \\ \hline \end{array} \right\rangle \\
j : \left\langle \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & a \\ \hline \end{array}, \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & b_3 \\ \hline \end{array} \right\rangle
\end{array}$$

Figure 1: Dynamic update of the sentence in (46)

3. \top and \perp are projection functions that map a list pair i to its top list (\top_i) and bottom list (\perp_i), respectively.
4. The operator \cdot appends an entity to a list, as visualized in the picture on the left. It also concatenate two lists, as visualized in the picture on the right.

$$\begin{array}{ccc}
\begin{array}{|c|c|} \hline 0 & 1 \\ \hline a & b \\ \hline \end{array} \cdot c & = & \begin{array}{|c|c|c|} \hline 0 & 1 & 2 \\ \hline a & b & c \\ \hline \end{array}
\end{array}
\qquad
\begin{array}{ccc}
\begin{array}{|c|c|} \hline 0 & 1 \\ \hline a & b \\ \hline \end{array} \cdot \begin{array}{|c|c|} \hline 0 & 1 \\ \hline c & d \\ \hline \end{array} & = & \begin{array}{|c|c|c|c|} \hline 0 & 1 & 2 & 3 \\ \hline a & b & c & d \\ \hline \end{array}
\end{array}$$

5. The basic types include individuals (type e), truth values (type t), possible worlds (type ω), lists (type σ). Info-states are pairs of lists (type $\sigma \times \sigma$). Dynamic propositions are type of $\omega \rightarrow (\sigma \times \sigma) \rightarrow (\sigma \times \sigma) \rightarrow t$, abbreviated as **t**.

To interpret (46), we feed it an input info-state, and the output is a set of list pairs which result from adding *Ann* to the input top list and a different boy to the input bottom list, as visualized in Figure 1. Since Ann bought multiple books and the update is nondeterministic, the resulting set is non-singleton.³⁰

Dividing drefs into two categories is important for retrieving the values of the dref introduced by a *wh*-expression. I'll return to this issue in Section 4.3.

4.2 Dynamicizing Hamblin Semantics

With the basic dynamic semantics in place, we are ready to dynamicize a question semantics. In the original Hamblin Semantics, the meaning of a question is a set of its possible propositional answers (Hamblin 1973, Kratzer & Shimoyama 2002, Shimoyama 2006). This set is generated by combining a *wh*-expression, which denotes a set of alternatives, and the rest of the sentence. As an example, *who* denotes a set of human entities, such as the set of men $\{ \llbracket \text{BOB} \rrbracket, \llbracket \text{SAM} \rrbracket \}$. This alternative set ‘expands’ with a suitable compositional process and finally generates a set of propositions, i.e., a Hamblin set, as the denotation of the question. An example of a Hamblin set is given on the left in (47).

$$(47) \quad \begin{array}{l} \llbracket \text{who saw Ann} \rrbracket = \\ \left\{ \begin{array}{l} \llbracket \text{BOB saw Ann} \rrbracket, \\ \llbracket \text{SAM saw Ann} \rrbracket \end{array} \right\} \rightsquigarrow \text{Dynamicization} \rightsquigarrow \begin{array}{l} \llbracket \text{who saw Ann} \rrbracket_d = \\ \left\{ \begin{array}{l} \llbracket \text{BOB saw Ann} \rrbracket_d, \\ \llbracket \text{SAM saw Ann} \rrbracket_d \end{array} \right\} \end{array} \end{array}$$

³⁰ This paper will not discuss the semantic contribution of focus, except Section 6.2, where I briefly show how Roothian semantics of focus (Rooth 1985, 1992; Kratzer 1991) is integrated into my analysis.

Upgrading the Hamblin Semantics to a dynamic semantics is relatively straightforward. All we need to do is assume that a Hamblin set is a set of dynamic propositions, rather than a set of static propositions, as assumed in the original Hamblin Semantics. A set of dynamic propositions is generated in an analogous way as static propositions, by compositionally expanding a set of alternatives introduced by a *wh*-expression. The only difference is that a *wh*-expression now denotes a set of *dynamic individuals* (modeled as dynamic generalized quantifiers, type $\mathbf{e} ::= (e \rightarrow \mathbf{t}) \rightarrow \mathbf{t}$), as shown in (48), instead of a set of static individuals. Each dynamic individual introduces a static individual (b, s) as a dref.

$$(48) \quad \llbracket \text{who} \rrbracket_d = \{ \llbracket \text{BOB} \rrbracket_d, \llbracket \text{SAM} \rrbracket_d \} = \overbrace{\{ \lambda P \lambda w \lambda i \lambda j. P(x) \wedge j = \langle \top_i, \perp_i \cdot x \rangle \mid x \in \{b, s\} \}}^{\text{dynamic individual}}$$

The status of *wh*-drefs As assumed in the last subsection, info-states are pairs of lists. I use these pairs to distinguish the *wh*-drefs from drefs introduced by non-*wh* expressions. As argued in Krifka (2001a), a *wh*-question is structured based on information structural properties. The non-*wh* portion of a question is background, whereas the *wh*-expression acts as the primary focus. This view is also supported by various studies on the prosody of *wh*-questions in Mandarin and Japanese (Ishihara 2003; Dong 2018; Yang 2018; a.o.), which show that the *wh*-expression must be the most prominent prosodically in a *wh*-question. When a focused non-*wh* phrase occurs in a *wh*-question, like *who only invited Ann_F*, this phrase may bear a secondary focus, instead of the primary focus. The difference in the information status has been used in Tomioka (2007) to account for that fact that the co-occurrence of a *wh*-expression and another primary focus leads to reduced acceptability.³¹ Piggybacking on the focus property of *wh*-expressions, they are assumed to introduce drefs to the bottom lists. By contrast, non-*wh* expressions introduce drefs to the top lists.³²

More precisely, a *wh*-expression introduces as drefs a set of alternative entities, each of which is associated with a different individual and is added to an input bottom list. Given (48), the *wh*-question *who saw Ann* denotes a set of dynamic propositions, as shown in (49).

$$(49) \quad \llbracket \text{who saw Ann} \rrbracket_d = \{ \llbracket \text{BOB saw Ann} \rrbracket_d, \llbracket \text{SAM saw Ann} \rrbracket_d \} \\ = \{ \lambda w \lambda i \lambda j. \text{see}_w(a)(x) \wedge j = \langle \top_i \cdot a, \perp_i \cdot x \rangle \mid x \in \{b, s\} \}$$

The intuition of the denotation in (49) is that the *wh*-question provides possible updates for an input context, as depicted in Figure 2. Each of the dynamic propositions in (49) updates the input context and generates an output. The addressee has to pick one out to update the

³¹ A *wh*-question can contain a non-*wh* expression that is prosodically prominent in some situations, like (i). The subject *Ann* in the final question bears an accent and contrasts with *Bob*.

(i) I am interested in what Ann and Bob ate. Let's start with Ann. What did [Ann]_{CT} eat?

It does not mean that *Ann* is the primary focus. In the literature, it is called a 'contrastive topic', which generates a set of questions not uttered explicitly (Büring 2003; Tomioka 2010; Constant 2014; Krifka 2017).

³² In this paper, I leave open the issue whether *wh*-expressions evoke focus alternatives like other focused expressions. One view is that *wh*-expressions only give rise to alternatives in the focus meaning dimension (Beck 2006; Kotek 2014; Kotek & Erlewine 2018; Dong 2018; Uegaki 2018). The other view is that *wh*-expressions inherently denote alternative sets and it is not necessary to assume that they evoke focus alternatives (Ishihara 2003; Eckardt 2007; Li & Law 2016). In order to avoid unnecessary complexity, I just use the original version of Hamblin Semantics and do not posit another dimensional meaning for *wh*-expressions.

$$i : \left\langle \begin{array}{|c|} \hline 0 \\ \hline \dots \\ \hline \end{array}, \begin{array}{|c|} \hline 0 \\ \hline \dots \\ \hline \end{array} \right\rangle \rightsquigarrow \llbracket \text{who saw Ann} \rrbracket_d \left\{ \begin{array}{l} \llbracket \text{Bob saw Ann} \rrbracket_d \rightsquigarrow j : \left\langle \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & a \\ \hline \end{array}, \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & b \\ \hline \end{array} \right\rangle \\ \llbracket \text{SAM saw Ann} \rrbracket_d \rightsquigarrow j : \left\langle \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & a \\ \hline \end{array}, \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & s \\ \hline \end{array} \right\rangle \end{array} \right\}$$

Figure 2: Dynamic update of the *wh*-question in (49)

context. This mechanism follows the spirit of the discourse dynamics of questions proposed in Farkas & Bruce (2010).³³

Composition The dynamic Hamblin Semantics can be made compositional in the same way that the static Hamblin Semantics can be (Kratzer & Shimoyama 2002; Shimoyama 2006). In particular, we can trivially shift a semantic value to a singleton set containing this value. Any two set denotations can be combined in a pointwise manner. A concrete derivation is given in (50). The result is a set of dynamic propositions.

$$\begin{aligned} (50) \quad \llbracket \text{who saw Ann} \rrbracket_d &= \llbracket \text{who} \rrbracket_d \circledast (\{ \llbracket \text{saw} \rrbracket_d \} \circledast \{ \llbracket \text{Ann} \rrbracket_d \}) \\ &= \llbracket \text{who} \rrbracket_d \circledast \{ \llbracket \text{saw} \rrbracket_d \bullet \llbracket \text{Ann} \rrbracket_d \} \\ &= \{ \beta \bullet \llbracket \text{saw} \rrbracket_d \bullet \llbracket \text{Ann} \rrbracket_d \mid \beta \in \llbracket \text{who} \rrbracket_d \} \\ &= \{ \llbracket \text{Bob} \rrbracket_d \bullet \llbracket \text{saw} \rrbracket_d \bullet \llbracket \text{Ann} \rrbracket_d, \llbracket \text{SAM} \rrbracket_d \bullet \llbracket \text{saw} \rrbracket_d \bullet \llbracket \text{Ann} \rrbracket_d \} \end{aligned}$$

Following Charlow (2017), \circledast embodies a pointwise compositional rule, defined in (51). It takes two sets, A and B , combines one member from A with another one from B and exhausts all combinations.

$$(51) \quad A \circledast B := \{ m \bullet n \mid m \in A \wedge n \in B \}$$

As dynamic semantic values, m and n are combined with the ordinary dynamic compositional rules (e.g. Muskens 1996). The detailed dynamic composition is deferred until Appendix A. For now, I use ‘ $m \bullet n$ ’ to signify the dynamic composition of m and n .

4.3 Retrieving values associated with *wh*-drefs

This subsection turns to the most important operation in my analysis—retrieving values associated with *wh*-drefs. This operation is not a castle in the air but is built from two known operations—Existential Disclosure and Answerhood Operator.

Existential Disclosure Drefs are retrievable in dynamic semantics. This property enables the definition of a retrieving operator on the values of *wh*-drefs. Dekker (1993) shows that dynamic propositions introducing drefs can be mapped to dynamic predicates. This mapping is called ‘Existential Disclosure’. I re-define it as in (52) to adapt it to the present dynamic framework.³⁴ Notationally, $\lambda x_1, x_2, \dots, x_n = \lambda x_1 \lambda x_2 \dots \lambda x_n$ and e^n is a sequence of e -types

³³ Murray (2010) assumes that a *wh*-question also introduces sets of possible worlds as drefs, which are added to the bottom lists. This assumption is not adopted in my analysis.

³⁴ Existential Disclosure defined in Dekker (1993) is couched in Dynamic Montague Grammar (Groenendijk &

of number n .

$$\begin{aligned}
 (52) \quad a. \quad \mathbf{ED}^\perp(\phi) &:= \overbrace{\lambda x_1, x_2, \dots, x_n}^{\text{values of drefs}} \underbrace{\lambda w \lambda i \lambda j. \phi(w)(i)(j) \wedge \perp_j - \perp_i = x_1 \cdot x_2 \cdot \dots \cdot x_n}_{\text{dynamic proposition}} \\
 b. \quad \mathbf{ED}^\top(\phi) &:= \lambda x_1, x_2, \dots, x_n \lambda w \lambda i \lambda j. \phi(w)(i)(j) \wedge \top_j - \top_i = x_1 \cdot x_2 \cdot \dots \cdot x_n \\
 &\quad \mathbf{ED} :: \mathbf{t} \rightarrow e^n \rightarrow \mathbf{t}
 \end{aligned}$$

$\mathbf{ED}^\perp(\phi)$ as a function characterizes a set of (sequences of) entities (x_1, x_2, \dots, x_n) that are introduced as drefs in the outputs of ϕ . In particular, \mathbf{ED}^\perp represents a retrieving process as follows: (i) it applies to a dynamic proposition ϕ , which maps an input info-state i to an output info-state j , (ii) it subtracts the bottom list in i from each bottom list in outputs (i.e., $\perp_j - \perp_i$), yielding a list of the variables x_1, x_2, \dots, x_n whose values must be associated with drefs in the outputs of ϕ , and (iii) these variables are abstracted over by being bound by λ .³⁵

Answerhood Operator Dayal (1996) defines an answerhood operator that picks out from a Hamblin set the strongest true proposition relative to a possible world. A dynamic counterpart of the answerhood operator is defined as in (53).

$$\begin{aligned}
 (53) \quad \mathbf{Ans}_{w,i}(Q) &:= \iota\phi \in Q, \text{ such that} \\
 a. \quad &\phi(w)(i) \text{ is dynamically true and} \\
 b. \quad &\text{for all } \psi \in Q, \text{ if } \psi(w)(i) \text{ is dynamically true, } \phi \text{ entails } \psi \text{ w.r.t } i
 \end{aligned}$$

The truth condition of dynamic propositions is defined via quantification over output list pairs, as in (54). The entailment between two dynamic propositions is defined as in (55).

$$(54) \quad \phi(w)(i) \text{ is dynamically true iff } \exists j. \phi(w)(i)(j) \text{ is true.}$$

$$(55) \quad \phi \text{ entails } \psi \text{ w.r.t } i \text{ iff } \forall j \forall w. \phi(w)(i)(j) \rightarrow \exists k. \psi(w)(j)(k)$$

Let's take the *wh*-question in (56) as a concrete example to see how **Ans** works. According to Dayal (1996), a number-neutral *wh*-expression like *who* can range over singular and plural individuals. The latter is formed via the sum operation \oplus (Link 1983). In the dynamic Hamblin semantics, *wh*-drefs introduced by *who* may include singular individuals and their sums. Because of the plural individual, I assume that the static properties and relations on which dynamic meanings are built are closed cumulatively. For example, given a world w , if $\text{late}_w(x)$ and $\text{late}_w(y)$, then $\text{late}_w(x \oplus y)$; if $\text{see}_w(x)(y)$ and $\text{see}_w(x')(y')$, then $\text{see}_w(x \oplus x')(y \oplus y')$.

Stokhof 1990) and exploits cross-sentential binding to retrieve drefs. By contrast, in my definition (52), the subtraction of lists is used to retrieve drefs. Both give rise to the same result in most cases, but the present definition has an advantage when retrieving values of *wh*-drefs in a multiple-*wh* question. A comparison of these two definitions is provided in Appendix B.

³⁵ Applying **ED** to the existential sentence *a girl won* results in a dynamic predicate, as in (i). As a result, **ED** seems to wipe out the existential operator (this is the reason why this operation is dubbed as Existential Disclosure).

$$\begin{aligned}
 (i) \quad \mathbf{ED}^\perp(\llbracket \text{a girl won} \rrbracket_d) &= \lambda y \lambda w \lambda i \lambda j. \exists x. \text{girl}_w(x) \wedge \text{win}_w(x) \wedge j = \langle \top_i, \perp_i \cdot x \rangle \wedge \perp_j - \perp_i = y \\
 &= \lambda y \lambda w \lambda i \lambda j. \exists x. \text{girl}_w(x) \wedge \text{win}_w(x) \wedge j = \langle \top_i, \perp_i \cdot x \rangle \wedge (\perp_i \cdot x) - \perp_i = y \\
 &= \lambda y \lambda w \lambda i \lambda j. \exists x. \text{girl}_w(x) \wedge \text{win}_w(x) \wedge j = \langle \top_i, \perp_i \cdot x \rangle \wedge x = y \\
 &= \lambda y \lambda w \lambda i \lambda j. \text{girl}_w(y) \wedge \text{win}_w(y) \wedge j = \langle \top_i, \perp_i \cdot y \rangle
 \end{aligned}$$

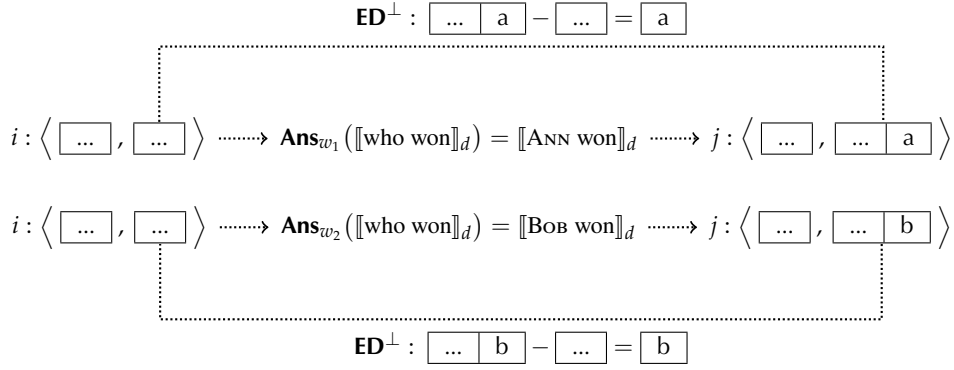


Figure 3: The process of retrieving values of *wh*-drefs

$$(56) \quad \llbracket \text{who was late} \rrbracket_d = \{ \lambda w \lambda i \lambda j. \text{late}_w(x) \wedge j = \langle \top_i, \perp_i \cdot x \rangle \mid x \in \{a, b, a \oplus b\} \} \\ = \{ \llbracket \text{ADA was late} \rrbracket_d, \llbracket \text{BOB was late} \rrbracket_d, \llbracket \text{ADA AND BOB were late} \rrbracket_d \}$$

Applying **Ans** to the *wh*-question in (56) yields the maximally informative dynamic proposition ϕ relative a possible word w and an input info-state i , i.e., ϕ is true in w and i and entails other true answers. Given the actual world w_0 and an input info-state i , if Ada and Bob both were late in w_0 , then $\llbracket \text{ADA AND BOB were late} \rrbracket_d$ is maximally informative relative to w_0 and i . This dynamic proposition is the complete propositional answer to the question.

Existential Disclosure + Answerhood operator With **ED** in hand, we can retrieve the values of *wh*-drefs. The retrieving process is depicted in Figure 3. Let's consider the question *who won* in a small model that only contains two people $\{a(\text{nn}), b(\text{ob})\}$ and two possible worlds $\{w_1, w_2\}$. The *wh*-expression *who* denotes a set of dynamic individuals containing $\llbracket \text{ANN} \rrbracket_d$ and $\llbracket \text{BOB} \rrbracket_d$, which introduce the individuals a and b as drefs respectively. Suppose that only Ann won in w_1 and only Bob won in w_2 , then the complete propositional answer to the question is $\llbracket \text{ANN won} \rrbracket_d$ in w_1 and $\llbracket \text{BOB won} \rrbracket_d$ in w_2 , according to the definition of **Ans** given in the last subsection. Each complete propositional answer is associated with a dref introduced by *who*. \mathbf{ED}^\perp applies to each complete answer and retrieves the values of the drefs stored in the output bottom lists, i.e., the drefs introduced by *who*.

The retrieving process is embodied by an operator **SA**, defined in (57). **SA** is a composition of \mathbf{ED}^\perp and **Ans**. Given a *wh*-question denoting a dynamicized Hamblin set Q , **Ans** picks out the complete answer ϕ in a possible world w from Q . Then, \mathbf{ED}^\perp shifts ϕ to a dynamic predicate of values associated with the drefs added by ϕ to an input bottom list. Thus, **SA** is a function mapping *sets of dynamic propositions* to dynamic predicates.

$$(57) \quad \mathbf{SA}(Q) := \mathbf{ED}^\perp(\mathbf{Ans}(Q)) \quad \mathbf{SA} :: \{t\} \rightarrow e^n \rightarrow t \\ = \lambda x_1, x_2 \dots x_n \lambda w \lambda i \lambda j. \underbrace{\llbracket \mathbf{Ans}_{w,i}(Q) \rrbracket}_{\phi}(w)(i)(j) \wedge \perp_j - \perp_i = x_1 \cdot x_2 \cdot \dots \cdot x_n$$

As in (58), **SA** transforms the meaning of *who won* to a predicate meaning. See Appendix A.3 for a detailed derivation. This predicate meaning characterizes a set of persons x such that x won in a possible world w and $[x \text{ won in } w]$ is the complete answer to *who won* in w .

$$\begin{aligned}
(58) \quad & [\mathbf{SA} \llbracket \text{who won} \rrbracket_d] \\
&= \lambda y \lambda w \lambda i \lambda j. [\mathbf{Ans}_{w,i} \llbracket \text{who won} \rrbracket_d] (w)(i)(j) \wedge \perp_j - \perp_i = y \\
&= \lambda y \lambda w \lambda i \lambda j. \text{human}_{w_0}(y) \wedge \text{win}_w(y) \wedge j = \langle \top_i, \perp_i \cdot y \rangle \wedge \\
&\quad [\mathbf{Ans}_{w,i} \llbracket \text{who won} \rrbracket_d] = [\lambda w' \lambda i' \lambda j'. \text{win}_{w'}(y) \wedge j' = \langle \top_{i'}, \perp_{i'} \cdot y \rangle]
\end{aligned}$$

Connection to short answers **SA** is short for ‘short answer’. The predicate meaning produced by **SA** precisely characterizes possible short answers to *wh*-questions. For (58), the entities that make it dynamically true are people who won in a possible world. Given the small model shown in Figure 3, the people would be Ann (relative to w_1) and Bob (relative to w_2). They are the possible short answers to *who won*. Because of this connection, the analysis of *wh*-conditionals that I am going to propose in the next section preserves the intuition shared in Liu’s (2016) and Xiang’s (2020) studies: *wh*-conditionals express question dependencies with respect to short answers.

Why divide drefs into two types Distinguishing two types of drefs is important for retrieving the values of the *wh*-drefs. In a *wh*-question, there can be lexical items, besides the *wh*-expression, that introduce drefs. For example, in the following question, the *wh*-expressions, *a man* and *Ann* introduce drefs.

(59) Who asked a man to send what to Ada?

If the info-state is a simple list

...

, this list will be extended as

...	x	y	z	a
-----	-----	-----	-----	-----

 (x is some value introduced by *who*; y by *a man*; z by *what*; a by *Ada*). In this case, we have to design a complex indexing mechanism to pick out x and z , which form a short answer to the question. By contrast, in the present system, only *wh*-drefs are added to the bottom list, while drefs introduced by other expressions are added to the top list. In other words, after being updated by a *wh*-question, the bottom list in the output info-state only stores the *wh*-drefs. Given this design feature, it is relatively simple to extract them.

5 Analysis of *wh*-conditionals

With the background on the dynamics of *wh*-questions, we are ready to turn to the analysis of *wh*-conditionals. Section 5.1 presents the analysis for *wh*-conditionals. 5.2 demonstrate how the analysis is extended to the *wh*-conditionals embedding conjunctions of *wh*-clauses. Section 5.3 explains why polar questions cannot be connected by a conditional.

5.1 Quantification over entities introduced as *wh*-drefs

Following the LKH approach, the antecedent of a conditional provides a domain restriction for a quantifier, which may be a (covert) modal or a (covert) quantificational adverb, while the consequent serves as the scope of the quantifier. These quantifiers quantify over possible worlds/situations as well as other variables when they are available, i.e., they unselectively bind variables (see also Chierchia 1992, 2000). Accordingly, we assign the following definition for a conditional without any overt modal or adverb.

$$\begin{aligned}
(60) \quad \llbracket A \text{ jiù } B \rrbracket_d &= \mathbf{NEC}_{\vec{x},w} [\llbracket A \rrbracket_d(\vec{x})(w)] : (\llbracket B \rrbracket_d(\vec{x})(w)) \\
&= \lambda w' \lambda i \lambda j. i = j \wedge \forall \vec{x}, w, k. (w \in R(w') \wedge \llbracket A \rrbracket_d(\vec{x})(w)(i)(k)) \\
&\quad \rightarrow \exists k'. \llbracket B \rrbracket_d(\vec{x})(s)(k)(k')
\end{aligned}$$

The conditional has a covert necessity modal **NEC**, which can bind possible world variables and any other variables in the restriction and scope, as assumed in Cheng & Huang (1996). $\llbracket A \rrbracket$ and $\llbracket B \rrbracket$ denote functions taking a world argument as well as an argument sequence \vec{x} of any length, including 0, and return a dynamic proposition.

Simple case In a *wh*-conditional, the restriction and scope of **NEC** are saturated by functions yielded by applying **SA** to *wh*-questions. As an illustration, consider (61). It can be interpreted as (62). **SA** transforms both *wh*-clauses into dynamic predicates. These predicate meanings serve as the restrictor and the scope of **NEC**.

- (61) Shéi shū-le, shéi 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.’

$$(62) \quad \mathbf{NEC}_{x,w} [\llbracket \mathbf{SA} [\text{who loses}] \rrbracket_d(x)(w)] : (\llbracket \mathbf{SA} [\text{who pays}] \rrbracket_d(x)(w))$$

In prose: for every world w and entity x s.t. x is introduced as a dref by the 1st instance of *who* and $[x \text{ loses}]$ completely answers *who loses* in w , x is introduced as a dref by the 2nd instance of *who* and $[x \text{ pays}]$ completely answers *who pays* in w .

In (62), **NEC** quantifies over the entities introduced as *wh*-drefs. For every x , $[x \text{ loses}]$ and $[x \text{ pays}]$ are both strongest answers to the relevant questions. So, (62) is equivalent to (63) below. In other words, the loser must be the payer. It derives the ‘co-reference’ of the two instances of *shéi* in (61).

- (63) For every world w and entity x s.t. x is the loser in w , x is the payer in w

‘Donkey’ anaphora in *wh*-conditionals Because of the dynamic nature, the present analysis can directly capture the ‘donkey’ anaphora shown in *wh*-conditionals (see Section 3). A relevant example is repeated in (64). Following Hua’s (2000) idea, the meaning of this sentence is formulated as in (65). The *wh*-expression in the consequent clause is related via a function f to the *wh*-expression in the antecedent clause. f maps kids to their fathers.

- (64) Nǎ-gè¹ háizi fàn-le cuò, nǎ-gè² jiāzhǎng jiù huì pīpíng tā₁.
 which-CL kid make-ASP mistake which-CL parent then will scold him
 ‘For every kid x , if x makes a mistake, x ’s parent is the one who will scold x .’

$$(65) \quad \mathbf{NEC}_{x,w} \left\{ \begin{array}{ll} \text{Restrictor} & \llbracket \mathbf{SA} [\text{which kid makes a mistake}] \rrbracket_d(x)(w) \\ & = \lambda i \lambda j. \text{kid}_{w_0}(x) \wedge \text{mistake}_w(x) \wedge j = \langle \top_i, \perp_i \cdot x \rangle \\ \text{Scope} & \llbracket \mathbf{SA} [\text{which parent scold him}_0^\perp] \rrbracket_d(f(x))(w) \\ & = \lambda i \lambda j. \text{parent}_{w_0}(f(x)) \wedge \text{scold}_w(\llbracket \text{him}_0^\perp \rrbracket_d)(f(x)) \wedge \\ & \quad j = \langle \top_i, \perp_i \cdot f(x) \rangle \end{array} \right.$$

NEC gives rise to universal quantification: given an input info-state i , for all individuals x , accessible worlds w and info-states k , if $\langle x, w, i, k \rangle$ makes the restrictor true, then there is an info-state k' such that $\langle x, w, k, k' \rangle$ makes the scope true. It should be noted that the *wh*-drefs are still accessible in info-states, though their values are abstracted over via SA. According to (65), the context updates can be depicted in Figure 4: if Bob (b) makes a mistake (b is fed Restrictor), then his parent ($f(b)$) will criticize him (referring to b); if Eric (e) makes a mistake (e is fed Restrictor), then his parent ($f(e)$) will criticize him (referring to e).

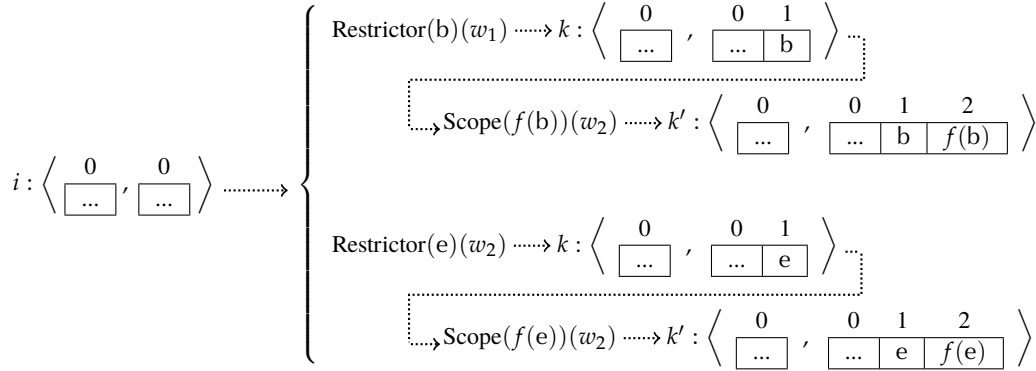


Figure 4: Sample updates involved in ‘donkey’ anaphora

The pronoun *him* bears two indices—the subscript 0 and the superscript \perp , which mean that the pronoun retrieves the dref stored in the last position of the input bottom list (See Appendix A for the formal definition of pronouns). In Figure 4, therefore, the pronoun refers to b or e, i.e., the kid who makes a mistake.

On one hand, this analysis retains the merit of the indefinite approach. That is, the meaning of *wh*-conditionals is compositionally built from the meaning of ordinary conditionals. Therefore, the morphological connection between the two types of conditionals is expected. On the other hand, this analysis also maintains the main idea of the question + categorial approach: the *wh*-conditional expresses the dependency of the short answers to the *wh*-questions. As discussed in Section 4.3, the entities introduced as *wh*-drefs form possible short answers to *wh*-questions. As a consequence, it is not surprising that the present analysis can capture the phenomena subsumed in previous approaches. Furthermore, I’m going to show in the following subsections the the present analysis also resolve the issues of these approaches pointed out in Section 2.

5.2 Retrieving *wh*-drefs introduced in conjunctions of *wh*-clauses

The present analysis can be principally extended to *wh*-conditionals embedding conjunctions of *wh*-clauses, like (66). The extension is given in (67).

- (66) Nǐ [chī **shěnmē** cài], tā [hē **shěnmē** jiǔ], Lǐbái jiù yào [chī **shěnmē** cài],
 you eat what dish he drink what wine Libai then must eat what dish
 [hē **shěnmē** jiǔ].
 drink what wine

‘For every dish x and every wine y , if x is what you eat and y is what he drinks, x is what I want to eat and y is what I want to drink.’

$$(67) \quad \text{must}_{\vec{x},w} \begin{cases} \text{Restrictor} & [\mathbf{SA} \llbracket \text{you eat wh.dish and he drinks wh.wine} \rrbracket_d] (\vec{x})(w) \\ \text{Scope} & [\mathbf{SA} \llbracket \text{I eat wh.dish and I drink wh.wine} \rrbracket_d] (\vec{x})(w) \end{cases}$$

In prose: for all accessible worlds w and sequences of entities \vec{x} , i.e., $[x_1, x_2]$ s.t. x_1 is the dish that you eat in w and x_2 is the wine that he drinks in w , x_1 is the dish that Libai eat in w and x_2 is the wine that Libai drink in w .

In (67), **SA** applies to both *wh*-clauses, providing the restrictor and the scope for the modal *yào* ‘must’, which quantifies over entities introduced as *wh*-drefs.

In the proposed semantics of *wh*-clauses, the denotations of various *wh*-clauses have a uniform type. Hence, conjoining *wh*-clauses is not an issue. To see this, suppose that the *wh*-conjuncts in the antecedent clause of (66) denote the sets (68) and (69), respectively.

$$(68) \quad \llbracket \text{you eat wh.dish} \rrbracket_d = \{ \llbracket \text{you eat SALAD} \rrbracket_d, \llbracket \text{you eat BEANS} \rrbracket_d \}$$

$$(69) \quad \llbracket \text{he drinks wh.wine} \rrbracket_d = \{ \llbracket \text{he drinks RED.WINE} \rrbracket_d, \llbracket \text{he drinks WHITE.WINE} \rrbracket_d \}$$

The two sets are conjoined in a pointwise manner (see Appendix A.2 for the definition of dynamic conjunction ‘ \triangle ’), giving rise to (70). The official derivation is in Appendix A.3.

$$(70) \quad \begin{aligned} & \{ \phi \triangle \psi \mid \phi \in \llbracket \text{you eat wh.dish} \rrbracket_d \wedge \psi \in \llbracket \text{he drinks wh.wine} \rrbracket_d \} \\ &= \left\{ \begin{array}{l} \llbracket \text{you eat SALAD} \rrbracket_d \triangle \llbracket \text{he drks R.W.} \rrbracket_d, \llbracket \text{you eat BEANS} \rrbracket_d \triangle \llbracket \text{he drks W.W.} \rrbracket_d, \\ \llbracket \text{you eat SALAD} \rrbracket_d \triangle \llbracket \text{he drks W.W.} \rrbracket_d, \llbracket \text{you eat BEANS} \rrbracket_d \triangle \llbracket \text{he drks R.W.} \rrbracket_d \end{array} \right\} \end{aligned}$$

The conjunction of *wh*-clauses denotes a set of conjunctions of dynamic propositions. Since salad, beans, red wine and white wine are all introduced by *wh*-expressions, they are added to the bottom list. As discussed in Section 4.3, the operator **SA** retrieves the values of the drefs introduced by *what dish* and *what wine*, as shown in (71).

$$(71) \quad \mathbf{SA}(70) := \lambda x \lambda y \lambda w. \lambda i \lambda j. [\mathbf{Ans}_{w,i}(70)](w)(i)(j) \wedge \perp_j - \perp_i = x \cdot y$$

$$\begin{aligned} i : \left\langle \begin{array}{|c|} \hline 0 \\ \hline \dots \\ \hline \end{array}, \begin{array}{|c|} \hline 0 \\ \hline \dots \\ \hline \end{array} \right\rangle & \rightsquigarrow \llbracket \text{you eat SALAD} \rrbracket_d \rightsquigarrow k : \left\langle \begin{array}{|c|} \hline 0 \\ \hline \dots \\ \hline \end{array}, \begin{array}{|c|c|} \hline 0 & 1 \\ \hline \dots & s \\ \hline \end{array} \right\rangle \rightsquigarrow \triangle \\ & \rightsquigarrow \llbracket \text{he drks R.W.} \rrbracket_d \rightsquigarrow j : \left\langle \begin{array}{|c|} \hline 0 \\ \hline \dots \\ \hline \end{array}, \begin{array}{|c|c|c|} \hline 0 & 1 & 2 \\ \hline \dots & s & \text{r.w.} \\ \hline \end{array} \right\rangle \end{aligned}$$

Figure 5: Context update of dynamic conjunction

Suppose that the first conjunction of dynamic propositions in (70) is picked out as the complete answer in a possible world w_1 . It updates an input info-state as depicted in Figure 5. The output bottom list $\perp_{i'}$ extends the input one \perp_i by adding salad and red wine. Then, $\perp_{i'} - \perp_i$ is $\begin{bmatrix} s & \text{r.w.} \end{bmatrix}$. Correspondingly, the food–wine sequence $[s, \text{r.w.}]$ and w_1 saturates the function in (71). Collecting the food–wine sequences retrieved relative to different

worlds together gives us a set of sequences. Returning to (67), this set restricts the domain of **must**. The scope of **must** is derived in the same way.

5.3 A-not-A questions

This subsection offers an account of the puzzle that conditionals can embed *wh*-questions but not A-not-A questions, a special type of polar questions, in Mandarin, as described in Section 2.2.2. For instance, (72) is not acceptable.

- (72) *Lǐbái kū-méi-kū, Dùfǔ jiù kū-méi-kǔ.
Libai cry-not-cry Dufu then cry-not-cry

From the perspective of dynamic semantics, I show that the contrast between *wh*-questions and A-not-A questions stems from the drefs introduced by the relevant question items. Unlike *wh*-expressions, A-not-A forms introduce drefs with determined values, which lead to a semantic/pragmatic defect when being quantified over in conditionals.

In dynamic semantics, verbs are assumed to introduce events as drefs (Dekker 1993; Bittner 2014; Henderson 2014). Assuming this is on the right track, the dref introduced by $\llbracket \text{cry} \rrbracket_d$ is a crying event. However, there is no conclusive evidence on whether $\llbracket \text{not cry} \rrbracket$ introduces any dref. This is because negation is typically taken to insulate any dref introduced in its scope. Empirically, I have not been able to find anaphora involving negated events in an A-not-A form. Consider (73).

- (73) Lǐbái $[\text{kū-méi-kū}]^1$? Tā lǎopó hǎoxiàng yǒu₁.
Libai cry-not-cry he wife seem exist
a. ‘Did Libai cry? It seems that his wife cried.’
b. #‘Did Libai cry? It seems that his wife didn’t cry.’

In this example, the existential verb *yǒu* ‘exist’ may refer to the event introduced by *kū-méi-kū* ‘cry-not-cry’ in the antecedent question. The subsequent sentence can only be understood as: the event that Libai’s wife cried exists. If $\llbracket \text{not cry} \rrbracket_d$ does not introduce any dref, then its inability to support anaphora is expected. Based on these considerations, there are two possible hypotheses as to what the status is of the dref introduced by an A-not-A form. **One possibility** is that an A-not-A form is decomposed into an A-not-A operator and a verb. The polar operator maps the verb meaning like $\llbracket \text{cry} \rrbracket_d$ into a set $\{\llbracket \text{cry} \rrbracket_d, [\text{not } \llbracket \text{cry} \rrbracket_d]\}$. The verb introduces an event as a dref, but the operator as a question item does not introduce any dref. **The other possibility** is that an A-not-A form simply introduces a V-ing event as a dref. According to the present analysis, this dref is added to the bottom list as it is introduced by a question item. We will consider both possible hypotheses in turn.

A semantic account If the first hypothesis is taken, an A-not-A question does not extend the bottom list in an input info-state. Then, applying **SA** to the set denoted by an A-not-A question gives rise to an empty set. This is because the polar operator is assumed to not introduce any dref and hence nothing can be retrieved by **SA**. Hence, the quantification given by a conditional is not defined if it embeds two polar questions.

A pragmatic account If the second hypothesis is taken, the ungrammaticality of (72) can be

understood as a result of a pragmatic blocking effect. As noticed by a reviewer, conditional constructions are not the only kind of environments where *wh*-questions and polar questions demonstrate a contrast. Certain verbs, like *surprise*, are able to embed *wh*-questions but not polar questions (Karttunen 1977), as in (74).

- (74) a. It is surprising who Bob had invited.
b. *It is surprising whether Bob had been invited.

Roelofsen et al. (2019) propose a blocking analysis for the contrast shown in (74). Their analysis relies on the difference of *wh*-questions and polar questions in terms of semantic objects that two types of questions bring into salience, i.e., the semantic objects that they highlight in the terminology of Roelofsen & Farkas (2015). Roelofsen et al. make sense of highlighted objects by assuming that they become available as drefs, serving as potential antecedents for subsequent anaphoric expressions. Concretely, the *wh*-question in (74-a) highlights a set of people possibly invited by Bob, i.e., the drefs introduced by *who*, whereas the polar question in (74-b) highlights the proposition ‘Bob had been invited’, which is introduced as a propositional dref. According to their definition, *surprise* is sensitive to highlighted objects and (74-b) is truth-conditionally equivalent to the sentence in (75).

- (75) It is surprising that Bob had been invited.

In pragmatics, a construction can be blocked by another simpler construction with the same interpretation. Based on the same reasoning, (74-b) is blocked by (75) because (75) is less complex than (74-b) in terms of the syntactic structure.³⁶

The blocking analysis can be extended to the unacceptability of (72). The selectional restriction of question embedding conditionals and that of question embedding verbs are uniformly determined by blocking effects generated based on the status of drefs introduced by question items. Assuming that an *A-not-A* form introduces an event as a dref, we can formulate (72) as (76), in which the two polar questions are transformed into functions characterizing sets of events. Under this hypothesis, both instances of *kū-méi-kū* only extends an input bottom list by adding a crying event as a dref.

- (76) $\text{NEC}_{e,w} \left[\left[\text{SA} \left[\left[\text{Libai cry-not-cry} \right]_d \right] (e)(w) \right] : \left(\left[\text{SA} \left[\left[\text{Dufu cry-not-cry} \right]_d \right] (e)(w) \right) \right)$

In prose: for every accessible world w and event e s.t. e is introduced as a dref by the 1st instance of *cry-not-cry* and [Libai participated in e] completely answers *did Libai cry* in w , e is introduced as a dref by the 2nd instance of *cry-not-cry* and [Dufu participated in e] completely answers *did Dufu cry* in w .

(76) can be paraphrased as: for every possible world w s.t. Libai cried in w , Dufu cried in w . As a result, it is truth-conditionally equivalent to the ordinary conditional in (77).

³⁶ The blocking effect is closely related to the Maxim of Manner, which requires that when two linguistic expressions are assertable, the simpler one should be used (Grice 1989; Katzir 2008). However, the blocking effect may not be derived from the Maxim of Manner, which generally does not lead to infelicity. Its status is more similar to the well known pragmatic constraint ‘Maximize Presupposition’ (Heim 1991; Sauerland 2008; Schlenker 2012; Lauer 2016; a.o.).

- (77) Lǐbái kū-le. Dùfǔ jiù kū-le.
 Libai cry-ASP Dufu then cry-ASP
 ‘If Libai cried, then Dufu cried.’

Note that the equivalence occurs systematically whenever a conditional embeds two *A-not-A* questions. As a result, the ordinary conditional in (77) blocks the conditional embedding *A-not-A* questions.

5.4 Interim summary

In short, the dynamic effect of *wh*-expressions, i.e., their ability to introduce drefs, makes it possible to connect the semantics of *wh*-questions and the semantics of conditionals to form *wh*-conditionals. Because *wh*-drefs are retrievable from the dynamic meaning of a *wh*-question, the question meaning can be mapped to a function characterizing entities that are introduced as *wh*-drefs. Such a function serves as an argument for the quantificational operator involved in a conditional. The proposed analysis not only captures the question-like properties of *wh*-conditionals and preserves the standard semantics of conditionals, but also does away with compositional issues found in alternative approaches.³⁷

6 Other properties of *wh*-conditionals

This section is devoted to three other properties of *wh*-conditionals, which have not been widely discussed in the literature. I show that they can be predicted by the present analysis in a principle way.

³⁷ If the present account is on the right track, the adverbial quantifier/modal involved in a conditional should have the potential to quantify over the values of drefs introduced by other expressions, like indefinites. However, two indefinites embedded in a conditional cannot co-refer, as shown in (i).

- (i) *Lǐbái qǐng-le [yí-gè rén]₁, Dùfǔ jiù yě huì qǐng [yí-gè rén]₁
 Libai invite-ASP one-CL person Dufu then too will invite one-ASP person
 Intended ‘If Libai invited a person, Dufu will invited this person.’

The unacceptability of (i) indicates that we would have to impose some sort of novelty condition for indefinites, as many dynamic theories assume (Heim 1982; Dekker 1996; a.o.). For example, the two occurrences of the indefinite *yí-gè rén* ‘a person’ must introduce distinct entities for drefs. Simultaneously, we have to prevent the application of the novelty condition for *wh*-expressions. In ordinary *wh*-questions, every occurrence of a *wh*-expression independently denotes a set of dynamic names. They do not form an anaphoric dependency. By contrast, in *wh*-conditionals, the values associated with *wh*-drefs are abstracted over by **SA** and become variables. If the novelty condition does not apply to *wh*-expressions, these variables can be bound by the same operator.

Chierchia (1995, 2000) proposes that it is possible to do away with the novelty condition. The effect of the novelty condition can be derived via a syntactic binding principle. Briefly, Chierchia re-defines syntactic binding: an argument *A* binds another argument *B* iff *A* and *B* are co-indexed and either (i) *A* c-commands *B* or (ii) *A* is co-indexed with a quantificational adverb that c-commands *B*. According to Chierchia, the syntactic structure of (i) is analyzed as (ii).

- (ii) [Libai invited [a person]₁] [ALWAYS₁ [Dufu will invite [a person]₁]]

In (ii), the first indefinite is co-indexed with the covert ALWAYS that c-commands the second indefinite. As a result, the first indefinite binds the second one. As a referential expression in the sense syntactic binding, the indefinite cannot be bound. In contrast, Chierchia postulates that *wh*-expressions are pronominal elements so that they can be bound in conditionals. However, it is not clear why *wh*-expressions are pronominal. Unlike pronouns, *wh*-expressions cannot be anaphoric to other expressions.

6.1 Maximality inference

As observed in previous studies, the consequent of a *wh*-conditional has a maximality inference (Luo & Crain 2011; Liu 2016; Wang 2016). For example, (78) indicates that the people invited by Dufu are exactly the ones invited by Libai. In other words, Dufu did not invite more people than Libai. Similarly, (79) indicates that the hearer should not fill her plate with more food than what she can eat.³⁸

- (78) Lǐbái qǐng-le shéi, Dùfǔ jiù qǐng-le shéi.
 Libai invite-ASP who Dufu then invite-ASP who
 ‘For every x , if x are the people invited by L, x are the people invited by D.’
- (79) Nǐ chī dūoshǎo, nǐ jiù chéng dūoshǎo.
 you eat how.much you then fill how.much
 ‘For every degree d , if d is the amount of the food that you can eat, d is the amount of the food that you should fill your plate with.’

In the present analysis, the meaning of (78) is represented as (80). **SA** is devised based on the the Dayal-style answerhood operator **Ans** (see (57)). **Ans** maps a question to its complete propositional answer, and **SA** retrieves from the output of the complete answer a set of entities which completely resolve the issue raised by the question in a world.

$$(80) \quad \text{NEC}_{x,w} \left[\left[\text{SA} \left[\text{who did L invite} \right]_d \right] (x)(w) \right] : \left(\left[\text{SA} \left[\text{who did D invite} \right]_d \right] (x)(w) \right)$$

According to (80), if *Ann and Bob* completely answers *who did Libai invite*, i.e., all people invited by Libai are Ann and Bob, it also completely answers *who did Dufu invite*, i.e., all people invited by Dufu are also Ann and Bob. The same analysis applies to (79).

³⁸ Xiang (2020a) challenges this observation based on examples like (i). The continuation indicates that the speaker will invite more people than the ones that the addressee would like to meet.

- (i) Nǐ xiǎng jiàn shéi, wǒ jiù yāoqǐng shéi. Dàn wǒ yě huì yāoqǐng qítā-rén.
 you want meet who, I jiu invite who. But I also will invite other-person
 ‘For every person x , if x is who you want to meet, x is who I will invite. But I will also invite some other people.’

However, there are at least two factors that may weaken this challenge. First, (i) becomes deviant without *dàn* ‘but’. It is known that *but* has a counter-expectational use. It indicates that the *wh*-conditional expresses an expectation that the speaker will invite only the people that the addressee wants to meet. According to previous studies (Winter & Rimon 1994; Toosarvandani 2014; a.o.), the expectation countered by *but* is a kind of weaker entailment rather than just a pragmatic implicature. Therefore, the fact that *dàn* is required here means that the *wh*-conditional does semantically give rise to a certain type of maximality inference. Second, (i) expresses an irrealis mood, i.e., the speaker’s invitation does not happen at the speech time. However, when a *wh*-conditional expresses a realis mood, the maximality inference cannot be wiped out, as shown in (ii).

- (ii) Dùfǔ qǐng-le shéi, Lǐbái jiù qǐng-le shéi. #Dàn Lǐbái yě yāoqǐng-le qítā rén.
 Dufu invite-ASP who Libai then invite-ASP who but Libai also invite-ASP other person
 ‘For every person x , if D invited x , x are the ones L invited. But L also invited other people.’

Due to these factors, the acceptability of (i) does not decisively show that *wh*-conditionals do not carry a maximality inference. The precise nature of the maximality inference would have to await future research.

6.2 Focus-related properties in *wh*-conditionals

The present analysis directly captures the phenomenon that the *wh*-expressions in a *wh*-conditional can associate with a focus sensitive particle, as described in Section 2.1.2. The relevant data is repeated in (81).

- (81) Qùnián tā **zhǐ** gěi shéi sòng-le lǐwù, jīnnián wǒ jiù **zhǐ** gěi shéi sòng lǐwù.
 last.year he only to who send-ASP gift this.year I then only to who send gift
 ‘For every x , if x is the only person that he sent a gifts to last year, x is the only person that I will send a gift to this year.’

Take the antecedent clause as an example. The *wh*-expression may denote a set of dynamic individuals with focus values, as visualized in (82). Compositionally, *only* is associated with these dynamic individuals one by one. As a result, the denotation of the antecedent clause looks like (83), which is the interpretation we want.

- (82) $\llbracket [\text{who}]_F \rrbracket_d = \{ \llbracket [\text{ANN}]_F \rrbracket_d, \llbracket [\text{BOB}]_F \rrbracket_d, \dots \}$
 (83) $\{ \llbracket [\text{he only sent } [\text{ANN}]_F \text{ gifts}]_d \rrbracket_d, \llbracket [\text{he only sent } [\text{BOB}]_F \text{ gifts}]_d \rrbracket_d, \dots \}$

I omit the concrete derivation of association with focus, which has been discussed at length in Rooth (1985, 1992), Kratzer (1991) and so on. I refer interested readers to these studies.

In addition, *wh*-conditionals exhibit focus intervention effects, as visualized in (84).³⁹ In these examples, the *wh*-expressions in both the antecedent and the consequent clause, as in (84-a), or in one of the clauses, as in (84-b), are preceded by a focus sensitive particle and its focused associate. The resulting configuration has been known to exhibit focus intervention effects and the *wh*-conditionals are indeed ill-formed.

- (84) a. ***Zhǐyǒu** [Lǐbái]_F qǐng-le shéi, [Dùfǔ]_F jiù tǎoyàn shéi.
 only Libai invite-ASP who Dufu then hate who
 Intended ‘For every x , if x are the people only invited by Libai, x are the people that Dufu hated.’
 b. ***Shì** [Lǐbái]_F diū-le shěnmē, Dùfǔ jiù mǎi shěnmē sòng tā.
 SHI Libai lose-ASP what Dufu then buy-ASP what send him
 Intended ‘For every x , if it was Libai who lost x , Dufu bought x for him.’

Although it is still debated what underlies focus intervention effects, many existing semantic analyses are established on Alternative Semantics (Beck 2006; Eckardt 2007; Li & Law 2016; Kotek 2017; Kotek & Erlewine 2018; a.o.). These studies assume that *wh*-expressions denote sets of alternatives (either at the ordinary dimension or at the focus dimension). Focus intervention effects result from the interaction of the alternatives evoked by *wh*-expressions and focus related elements. Since the present analysis is built on Hamblin Semantics, which is a type of Alternative Semantics, it can straightforwardly incorporate extant analyses of focus intervention effects based on Alternative Semantics to account for similar effects in *wh*-conditionals.

³⁹ Li & Law (2016) show that focus intervention effects are not restricted into *wh*-questions, but also appear in unconditionals, existential-*wh* constructions and disjunctive sentences.

Concretely, let me sketch an analysis for focus intervention effects in *wh*-conditionals. Among previous studies, the proposal due to Eckardt (2007) and Li & Law (2016) is least expressive representationally so it is used for illustration here. Consider (84-a). In the antecedent clause, the focus sensitive particle *zhǐyǒu* ‘only’ scopes over not only the focused expression but also the *wh*-expression. Following the Roothian multi-dimensional semantics (Rooth 1985, 1992; Kratzer 1991), the focused expression gives rise to a set of alternatives (i.e., $[\text{Alt } \llbracket \text{Libai} \rrbracket_d] := \{ \llbracket \text{Libai} \rrbracket_d, \llbracket \text{Dufu} \rrbracket_d, \dots \}$) at the focus dimension, which is distinct from the ordinary dimension. The ordinary value of the prejacent of *zhǐyǒu* is thus a set of dynamic proposition, as in (85). Based on the ordinary value, the focus value is generated by replacing the meaning of the focused expression with its alternatives, as in (86), resulting in a set of sets of dynamic propositions.

$$(85) \quad \llbracket [\text{Libai}]_F \text{ invited who} \rrbracket_d = \{ \llbracket \text{Libai} \rrbracket_d \bullet \llbracket \text{invited} \rrbracket_d \bullet \beta \mid \beta \in \llbracket \text{who} \rrbracket_d \}$$

$$(86) \quad \llbracket [\text{Libai}]_F \text{ invited who} \rrbracket_d^f = \{ \{ \beta' \bullet \llbracket \text{invited} \rrbracket_d \bullet \beta \mid \beta \in \llbracket \text{who} \rrbracket_d \} \mid \beta' \in [\text{Alt } \llbracket \text{Libai} \rrbracket_d] \}$$

As a focus sensitive particle, *zhǐyǒu* takes the focus value in (86) as its quantificational domain (Rooth 1985, 1992). However, it requires its domain to be a set containing propositional meanings, instead of a set of sets of propositional meanings. As a consequence, *zhǐyǒu* cannot combine with its prejacent, leading to the unacceptability.

6.3 Pair-list readings in multiple-*wh* conditionals

In a *wh*-conditional, the antecedent clause and the consequent clause can involve multiple *wh*-expressions, as illustrated in (87). In this paper, I call this kind of *wh*-conditional a ‘multiple-*wh* conditional’.

- (87) Zhè-zhǒng yànhuì shàng, nǎ-gè rén diǎn-le shěnmē, nǎ-gè rén
 this.kind banquet up which-CL person order-CL what which-CL person
 jiù chī-le shěnmē.
 then eat-ASP what
 ‘At this type of banquets, what everyone ate are the dishes that they ordered.’

Suppose that today’s banquet only has three guests, Ann, Eric, Carl, and they each ordered a dish. (87) is true only if each person ate the dish that s/he ordered. Intuitively, the antecedent multiple-*wh* clause establishes a list of person–dish pairs, and these pairs also verifies the eating relation in the consequent clause.

According to the present analysis, the *wh*-clauses embedded in a *wh*-conditional denote question meanings. Hence, it is predicted that the multiple-*wh* clauses in (87) should also demonstrate hallmark properties of multiple-*wh* questions. In this subsection, I discuss one of these properties, namely the availability of the pair-list readings. Specifically, I analyze the meaning of (87) as quantification over lists of person–dish pairs, as in (88).

- (88) For every situation *s* and a list of person–dish pairs $[x_1, y_1, x_2, y_2, \dots]$ s.t. x_1 ordered y_1 , x_2 ordered y_2 , and ... in *s*, x_1 ate y_1 , x_2 ate y_2 , and ... in *s*.

The pair-list reading is generated because the multiple-*wh* clauses in (88) share the denota-

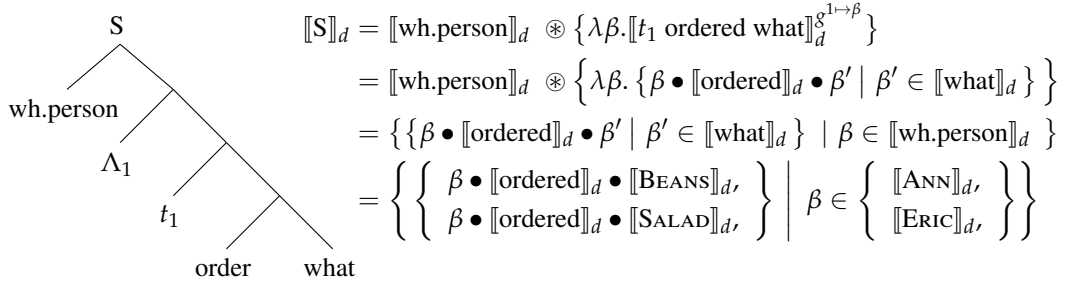


Figure 6: A multiple-*wh* question generates a higher order alternatives

tions with the corresponding multiple-*wh* questions admitting pair-list answers.⁴⁰

6.3.1 Generating pair-list readings

The analysis that I’m going to propose captures a basic intuition: a pair-list response divides a multiple-*wh* question about a family of individuals, like (89-a), into a family of questions about singular individuals as in (89-b); the response is then a composite of answers to the individual sub-questions of the original interrogative, as in (89-c).

- (89) a. Which person ordered what?
b. { What did Ann order?, What did Eric order?, ... }
c. Ann ordered salad; Eric ordered beans; ...

In the literature, the intuition has been formalized in Hagstrom (1998), Willis (2008), Fox (2012), Nicolae (2013), Constant (2014) and Kotek (2014) based on the static Hamblin Semantics. Along the same line, I derive the meaning of a multiple-*wh* question in the way depicted in Figure 6. The *wh*-subject undergoes movement at LF and triggers λ -abstraction. The composition results in a set of sets of dynamic propositions. Suppose that *which person* ranges over *Ann* and *Eric*, and *what* ranges over *salad* and *beans*, then the resulting set looks like (90). This set can also be seen as a set of questions.⁴¹

⁴⁰ It is observed that multiple-*wh*-questions can also admit single-pair answers, as in (i). Correspondingly, multiple-*wh* conditionals also have a ‘single-pair’ reading, as in (ii). Its meaning can be represented as: for every accessible world w and two people x and y , if x hits y first in w , then x apologizes to y in w .

- (i) A: Who hit who first? B: Bob hit Carl first.
(ii) Shéi xiān dǎ-le shéi, shéi jiù yào gēn shéi dàoqiàn.
who first hit-ASP who who then must with who apologize
‘No matter who hit who first, he must apologize to him.’

Both examples are felicitous when the context involves only two people and one hit the other first. So, the question in (i) is resolved by a single pair of two people and the multiple-*wh* conditional in (ii) quantifies over single pairs of people. This reading can be derived via the basic composition of question meaning, i.e., $\llbracket \text{who hit who first} \rrbracket_d = \llbracket \text{who} \rrbracket_d \otimes (\{ \llbracket \text{hit} \rrbracket_d \} \otimes \llbracket \text{who} \rrbracket_d) = \{ \beta \bullet \llbracket \text{hit} \rrbracket_d \bullet \beta' \mid \beta, \beta' \in \llbracket \text{who} \rrbracket_d \}$

⁴¹ In addition to the set-of-questions approach followed by this paper, there is a functional approach to the pair-list readings of multiple-*wh* questions (Engdahl 1986; Chierchia 1993; Dayal 1996; Xiang 2020b). The functional approach argues that a multiple-*wh* question with a pair-list reading is asking about a function from entities to entities. The present study is neutral to both approaches. The set-of-questions approach is chosen because it is employed in the studies assuming Hamblin Semantics, such as Constant (2014) and Kotek (2014).

$$(90) \quad \left\{ \left\{ \begin{array}{l} \llbracket \text{ANN ordered SALAD} \rrbracket_d, \\ \llbracket \text{ANN ordered BEANS} \rrbracket_d \end{array} \right\}, \left\{ \begin{array}{l} \llbracket \text{ERIC ordered SALAD} \rrbracket_d, \\ \llbracket \text{ERIC ordered BEANS} \rrbracket_d \end{array} \right\} \right\} \\ = \{ \llbracket \text{what did ANN order} \rrbracket_d, \llbracket \text{what did ERIC order} \rrbracket_d \}$$

I apply an operator \sqcap , which is defined as in (91), to the result. It shifts a set of questions to a set of dynamic propositions, i.e., the ordinary question meaning.

$$(91) \quad \sqcap \{Q_1, \dots, Q_n\} := \{\phi \triangle \psi \triangle \dots \triangle \gamma \mid \phi \in Q_1 \wedge \psi \in Q_2 \wedge \dots \wedge \gamma \in Q_n\}$$

This operator iteratively picks one member from each set of dynamic propositions and conjoins them, as illustrated in (92). Interpreting each conjunction of dynamic propositions in the set yields (92), in which each member updates the input list pair by adding a list of entities alternating between people and dishes to the bottom list.⁴²

$$(92) \quad \left\{ \begin{array}{l} \llbracket \text{ANN ordered SALAD} \rrbracket_d \triangle \llbracket \text{ERIC ordered BEANS} \rrbracket_d, \\ \llbracket \text{ANN ordered BEANS} \rrbracket_d \triangle \llbracket \text{ERIC ordered SALAD} \rrbracket_d, \\ \llbracket \text{ANN ordered SALAD} \rrbracket_d \triangle \llbracket \text{ERIC ordered SALAD} \rrbracket_d, \\ \llbracket \text{ANN ordered BEANS} \rrbracket_d \triangle \llbracket \text{ERIC ordered BEANS} \rrbracket_d \end{array} \right\} \\ = \left\{ \lambda w \lambda i \lambda j. \left[\begin{array}{l} \text{order}_w(y_1)(a) \wedge \text{turn}_w(y_2)(e) \\ \wedge j = \langle \top_i, \perp_i \cdot a \cdot y_1 \cdot e \cdot y_2 \rangle \end{array} \right] \mid y_1, y_2 \in \{s, b\} \right\} \\ = \left\{ \begin{array}{l} \lambda w \lambda i \lambda j. \text{order}_w(s)(a) \wedge \text{order}_w(b)(e) \wedge j = \langle \top_i, \perp_i \cdot a \cdot s \cdot e \cdot b \rangle, \\ \lambda w \lambda i \lambda j. \text{order}_w(s)(a) \wedge \text{order}_w(b)(e) \wedge j = \langle \top_i, \perp_i \cdot a \cdot b \cdot e \cdot s \rangle, \dots \end{array} \right\}$$

Applying **SA** to the resulting set in (92) produces a dynamic predicate as in (93). This dynamic predicate characterizes a set of sequences containing the highlighted ones in (92).

$$(93) \quad \mathbf{SA}(92) = \lambda x_1, y_1, x_2, y_2 \lambda w \lambda i \lambda j. [\mathbf{Ans}_{w,i}(92)](w)(i)(j) \wedge \perp_j - \perp_i = x_1 \cdot y_1 \cdot x_2 \cdot y_2$$

In other words, a sequence of entities that makes (93) dynamically true in a possible world must be one with individuals alternating between people and dishes, as shown below:

$$w_1 : [\text{ann, salad, eric, beans}] \quad w_2 : [\text{ann, beans, eric, salad}] \quad \dots$$

These sequences are considered possible short answers to *which person ordered what*. Each of them can be decomposed into two subparts containing a person and a dish, and hence offers a list of person–dish sequences to resolve the issue raised by the multiple-*wh* question.

Returning to the multiple-*wh* conditional in (87), repeated in (94), its meaning is represented as (95) in the present analysis.

⁴² In dynamic semantics, the present analysis is close to Bumford's (2015) account of the pair-list reading in questions with quantifiers (e.g., the availability of pair-list readings in questions like *which dish did everyone order*). In his account, the dependency established in a pair-list answer to *who ordered which dish* is also represented as a list of entities alternating between people and dishes.

- (94) Zhè-zhǒng yànhuì shàng, nǎ-gè rén diǎn-le shěnmē, nǎ-gè rén
 this.kind banquet up which-CL person order-CL what which-CL person
 jiù chī-le shěnmē.
 then eat-ASP what
 ‘At this type of banquets, what everyone ate are the dishes that they ordered.’
- (95) $\text{NEC}_{\vec{x},w} \left\{ \begin{array}{ll} \text{Restrictor} & [\text{SA } \llbracket \text{wh.person ordered what} \rrbracket_d] (\vec{x})(w) \\ \text{Scope} & [\text{SA } \llbracket \text{wh.person ate what} \rrbracket_d] (\vec{x})(w) \end{array} \right.$

In this representation, ALWAYS quantifies over sequences of entities alternating between people and dishes. Given a possible world w in which Ann ordered salad and Eric beans, the sequence [ann, salad, eric, beans] saturates $[\text{SA } \llbracket \text{wh.person ordered what} \rrbracket_d]$ in w . According to (95), this sequence also saturates $[\text{SA } \llbracket \text{wh.person ate what} \rrbracket_d]$ in w , i.e., Ann ate salad and Eric beans in w . Therefore, (95) guarantees that in every situation the dish that a person ate must be the one that s/he ordered.

6.3.2 Quantification over lists of pairs

In the present analysis of multiple-*wh* conditionals, lists of pairs are quantified over. This is attested in *wh*-conditionals containing overt adverbial quantifiers. Consider (96), which contains the adverbial quantifier *tōngcháng* ‘usually’. In my analysis, (96) can be interpreted along the lines of (97).⁴³

- (96) Tōngcháng, zài yànhuì shàng, nǎ-gè rén diǎn-le shěnmē, nǎ-gè rén
 usually at banquet up which-CL person order-CL what which-CL
 rén jiù chī-le shěnmē.
 person then eat-ASP what
 ‘Usually, at a banquet, what everyone ate the dishes that they ordered.’

- (97) $\text{usually}_{\vec{x},s} \left\{ \begin{array}{ll} \text{Restrictor} & [\text{SA } \llbracket \text{wh.person ordered what} \rrbracket_d] (\vec{x})(s) \\ \text{Scope} & [\text{SA } \llbracket \text{wh.person ate what} \rrbracket_d] (\vec{x})(s) \end{array} \right.$

In prose: for most situations s and sequences of entities \vec{x} (lists of person–dish pairs) s.t. \vec{x} completely resolves the issue raised by *which person ordered what* in s , \vec{x} completely resolves the issue raised by *which person ate what* in s .

Note that the adverbial quantifies over both a situation s and a sequence of entities \vec{x} . Accordingly, the *wh*-conditional in (96) is true in the following scenario.

situation	short answer to <i>wh.one ordered what</i>	short answer to <i>wh.one ate what</i>
s_1	Ann, beans; Bob, salad+beans; Carl, tofu	Ann, beans; Bob, salad+beans; Carl, tofu
s_2	Ann, beans; Bob, tofu; Carl, salad+tofu	Ann, beans; Bob, tofu; Carl, salad+tofu
s_3	Ann, beans+tofu; Bob, beans; Carl, salad	Ann, beans; Bob, tofu; Carl, salad

⁴³ In this paper, I consider a situation part of a possible world, following Kratzer (1989, 2002), and simply assume that situations are in the same domain as possible worlds. So, a situation s can saturate the world arguments of the functions shifted by the application of SA to the *wh*-clauses.

Each situation is associated with a *complete* list in which all people are paired with at least one dish. As a result, it is not possible that one situation is paired with two different lists of dishes. So, quantifying over pairs of a situation s and the list of entities in s in (97) is the same as quantifying over only situations. Hence, (96) says that in most situations s such that everyone ordered dishes in s , each of them ate the dishes that they ordered in s . This is the truth condition that we want.

(96) cannot be analyzed as quantification over a variable over people and another variable over dishes, like (98).⁴⁴ Differing from (97), the truth condition in (98) calculates the proportion based on pairs consisting of one person and one dish, rather than lists of multiple person–dish pairs.

(98) For most situations s , people x and dishes y s.t. x ordered y , x ate y

It is too weak and would predict that (96) is true in the following two scenarios.⁴⁵

situations	order	eat	situations	order	eat
s_1	(Ann, salad)	(Ann, salad)	s_1	(Ann, salad)	(Ann, salad)
s_1	(Bob, beans)	(Bob, beans)	s_1	(Ann, beans)	
s_1	(Cleo, salad)	(Cleo, salad)	s_1	(Cleo, beans)	(Cleo, beans)
s_1	(Tim, salad)	(Tim, salad)	s_1	(Cleo, salad)	
s_1	(Eva, beans)	(Eva, beans)	s_2	(Eva, beans)	(Eva, beans)
s_1	(Ivy, beans)	(Ivy, beans)	s_2	(Ivy, beans)	(Ivy, beans)
s_2	(Eva, salad)	(Eva, beans)	s_3	(Eva, salad)	(Eva, salad)
s_2	(Bob, beans)	(Bob, salad)	s_3	(Eva, beans)	
s_3	(Cleo, beans)	(Cleo, salad)	s_3	(Cleo, beans)	(Cleo, beans)
s_3	(Ann, salad)	(Ann, beans)	s_3	(Cleo, salad)	

The rows shaded in gray each contain a situation s , a person x and a dish y such that x ordered and ate y in s . In both scenarios, six out of the ten rows are shaded in gray, i.e., for

⁴⁴ de Swart (1991) argues that quantificational adverbs quantifies over events or situations. This view is not incompatible with unselective binding. In (98), the situation variable is also bound by the quantificational adverb. Moreover, for the indefinite approach, the *wh*-expressions in (96) have to be bound by the same quantificational operator. Otherwise, the co-reference of the *wh*-expressions would not be explained.

⁴⁵ One way to repair (98) is to assume that the *wh*-expressions in (96) introduce variables ranging over a maximal set of people and a maximal set of dishes (cf. Chierchia 2000; Simon Charlow p.c.). In other words, (98) is revised as ‘for most situation s , a maximal set of people X and a maximal set of dishes Y s.t. X ordered Y , X ate Y ’. This solution may work when *wh*-expressions are number neutral, like *who* or *what*. However, in (96), the first *wh*-expression *nǎ-gè rén* ‘which person’ can only range over singular entities, because of the singular classifier *gè*. Moreover, even if the second *wh*-expression in (96) is changed to a morphologically singular one, as in (i), the sentence has the same meaning except it presupposes that everyone ordered one dish.

(i) Tōngcháng, zài yànhuì shàng, nǎ-gè rén diǎn-le nǎ-dào cài, nǎ-gè rén jiù
usually at banquet up which-CL person order-CL which-CL dish which-CL person then
chī-le nǎ-dào cài.
eat-ASP which-CL dish
‘Usually, at a banquet, what everyone ate the dishes that they ordered.’

In addition, Huang (2018) modifies Cheng & Huang’s (1996) analysis and suggests that the variables contributed by *wh*-expressions be invariably bound by a universal operator in *wh*-conditionals, instead of the operator offered by a conditional. This modified analysis may avoid the first problem, but it is not clear where the universal operator comes from compositionally. The quantificational force of a conditional is not always universal but varies along with adverbials/modals included in it.

most of the person–dish pairs $[x, y]$ such that x ordered y , x ate y . In the scenario on the left, the situation s_1 involves most pairs of a person x and a dish y such that x ordered y and also ate y . In the scenario on the right, the people involved in s_1 and s_3 ordered two dishes but only ate one. Both scenarios verifies the proportion calculated based on person–dish pairs. However, the sentence in (96) is judged false. It is true only if for most situations, everyone ate all dishes that he ordered.

The same pattern is also observed when conditionals provide existential quantification. For example, in (99), the *wh*-conditional contains the adverb *yǒushí* ‘sometimes’, which brings existential quantificational force.

- (99) Yǒushí, zài yànhuì shàng, nǎ-gè rén diǎn-le shěnmē, nǎ-gè rén
 sometimes at banquet up which-CL person order-CL what which-CL person
 jiù chī-le shěnmē.
 then eat-ASP what
 ‘Sometimes, at a banquet, what everyone ate the dishes that they ordered.’

Given a set of people and a set of dishes, this sentence is true only if there is at least one situation in which everyone ordered a dish and ate the dish that s/he ordered. By contrast, it is false if in every situation only one of the people ordered a dish and ate it.

7 Remaining issues

There are some issues pertaining to *wh*-conditionals that have not been addressed in this paper, but that do not necessarily create insurmountable difficulties.

A morphological identity requirement As pointed out in Cheng & Huang (1996), the ‘co-referential’ *wh*-expressions in a *wh*-conditional must share the same lexical form (see also Bruening & Tran 2006; Chen 2020). For example, in (100), although *nǎ-gè niánqīngrén* and *nǎ-gè qīngnián* both mean ‘which youth’, they are not interchangeable in the consequent clause. Intuitively, when the second *wh*-expression is *nǎ-gè qīngnián*, it cannot refer to the same youth as the first *wh*-expression does.

- (100) Nǎ-gè niánqīngrén shū-le, nǎ-gè {niánqīngrén / *qīngnián} jiù qǐngkè.
 which-CL youth lose-ASP which-CL youth youth then pay
 ‘For every youth x , if x is the one losing the bet, x is the one paying.’

The present semantic account (as well as Liu (2016) and Xiang (2020a)) only requires the identity of the values associated with *wh*-drefs in a *wh*-conditional. It does not expect the morphological identity.

In Section 3, I show that in some *wh*-conditionals the *wh*-expressions do not co-refer but are functionally related. One of the relevant examples is repeated in (101), where the second *wh*-expression must range over the parents of the kids ranged over by the first *wh*-expression. Following Hua (2000), I analyze the meaning of (101) as (102). A function f from kids to parents applies in the scope to link the two *wh*-expressions.

- (101) Nǎ-gè¹ háizi fàn-le cuò, nǎ-gè² jiāzhǎng jiù huì pīpíng tā₁.
 which-CL kid make-ASP mistake which-CL parent then must criticize him
 ‘For every kid x , if x makes a mistake, x ’s parent is the one who will criticize x .’
- (102) **must** _{x,w} [[SA [wh.kid mistake] _{d}] (x)(w)] : ([SA [wh.parent penlz] _{d}] ($f(x)$)(w))

The functional dependency may be generalized to all cases of *wh*-conditionals. For an ordinary case, like (100), the function involved there is an identity function f_{id} . (100) can be represented as (103). Because of the nature of the identity function, adding it to the semantic representation of the *wh*-conditional will not affect the present analysis.

- (103) **NEC** _{x,w} [[SA ([wh.youth loses] _{d}] (x)(w))] : ([SA ([wh.youth pays] _{d}] ($f_{id}(x)$)(w)))

Moreover, I conjecture that the application of f_{id} is signaled by the morphological identity. The *wh*-conditional in (100) with f_{id} requires both *wh*-expressions to share the same form.

Mention-some readings Xiang (2016, 2020a) and Liu (2016, 2017) notice that a *wh*-conditional is interpreted existentially when the antecedent clause can be understood as a mention-some *wh*-question. Consider (104), which means that the speaker will go to one but not all of the places where s/he can buy wine.

- (104) Nǎr néng mǎidào jiǔ, wǒ jiù qù nǎr.
 where can buy wine I then go where
 a. ‘I will go to some place(s) where I can buy wine.’
 b. ‘#I will go to (all) the places where I can buy wine.’

Crucially, the antecedent *wh*-clause has a mention-some interpretation when it is used as a question. For example, the answer to the question in (105) by no means infers that Costco is the only place that A can buy wine. This kind of questions is conventionally called ‘mention-some questions’ (Groenendijk & Stokhof 1984).

- (105) A: Nǎr néng mǎidào jiǔ? B: Costco.
 where can buy wine
 ‘Where can I buy wine?’

In both Liu’s and Xiang’s studies, *wh*-clauses in *wh*-conditionals are analyzed as *wh*-questions. They link the existential reading of (104) to the mention-some reading shown in (105).

Although the present analysis is also a question-based approach to *wh*-conditionals, it does not offer a direct way to capture the existential interpretation of (104). This is because the retrieving operator **SA** is built on Dayal’s (1996) Answerhood operator, which only gives rise to the strongest true answer to a question (see Section 4.3). As a result, applying **SA** to the antecedent *wh*-clause in (104) retrieves all the places which sell wine in a world.

In order to resolve this issue, the present analysis has to derive mention-some readings of *wh*-questions first. However, presenting a full-fledged derivation of the mention-some readings is beyond the scope of this paper. I can only sketch a potential solution in this subsection. Along the line of Dayal (1996), Fox (2013) and Xiang (2016) re-define the answerhood operator, which maps an ordinary *wh*-question to a *singleton* set of the strongest

true answer while a mention-some *wh*-question to a set of multiple true answers. According to their analysis, we can get the following answer sets.

- (106) a. For the ordinary *wh*-question *who lost*, the answer set is:
 $\{\llbracket \text{Bob and Eric lost} \rrbracket_d\}$, given that Bob and Eric both lost
- b. For the mention-some question *where can I buy wine*, the answer set is:
 $\left\{ \begin{array}{l} \llbracket \text{you can buy wine at Costco} \rrbracket_d, \\ \llbracket \text{you can buy wine at Walmart} \rrbracket_d \end{array} \right\}$, given that Costco and Walmart both sell wine

Adopting the re-defined answerhood operator, **SA** can be modified as in (107). Inspired by Xiang (2016, 2020a) and Liu (2016, 2017), I assume that a choice function f_{CH} applies between the answerhood operator and Existential Disclosure. f_{CH} is a partial function from sets of true answers that picks *only one* true answer from any non-empty set in its domain. In this sense, $f_{\text{CH}}(\text{Ans}_{\text{Fox-Xiang}}(Q))$ denotes a certain true answer picked out from the set given by $\text{Ans}_{\text{Fox-Xiang}}(Q)$.⁴⁶

$$(107) \quad \text{SA}'(Q) := \text{ED}^\perp \left(\underbrace{f_{\text{CH}}(\text{Ans}_{\text{Fox-Xiang}}(Q))}_{\text{a certain true answer } \phi} \right) \quad \text{SA}' :: \{t\} \rightarrow e^n \rightarrow t$$

If the answer set is (106-a), the member picked out by f_{CH} must be the strongest true answer that list all losers. This result is equivalent to the one generated via Dayal's answerhood operator. By contrast, if the answer set is (106-b), the member picked out by f_{CH} is just one true answer that mentions one wine store.

With **SA'**, the meaning of (104) can be represented as (108).

$$(108) \quad \text{NEC}_{x,w} \left[[\text{SA}' \llbracket \text{where can I buy wine} \rrbracket_d] (x)(w) \right] : ([\text{SA}' \llbracket \text{I go where} \rrbracket_d] (x)(w))$$

It says: for every accessible world w and place x , if x is a certain place chosen from where the speaker can buy wine in w , then x is the place where the speaker will go. Given a possible world w_1 in which Costco and Walmart sell wine, the choice function encoded in **SA'** yields one of the stores, either Costco or Walmart. So, in w_1 , the speaker can buy wine at either Costco or Walmart and s/he will go to this store, not both. Accordingly, the scenario verifying (108) is that the speaker will go to only one liquor store in every possible world.⁴⁷

⁴⁶ The value of the choice function f_{CH} is contextually determined, as Kratzer (1998) proposes when she implements the meaning of specific indefinites.

⁴⁷ The same kind of mention-some readings is also available for *wh*-conditionals with overt quantificational adverb, as shown in (i). The meaning of this sentence is represented as (ii).

(i) Tōngcháng, nǎ néng mǎidào jiǔ, wǒ jiù qù nǎ.
 usually where can buy wine I then go where
 'In most situations, I will go to some place(s) where I can buy wine.'

(ii) **usually** _{x,s} $[[\text{SA}' \llbracket \text{where can I buy wine} \rrbracket_d] (x)(s)] : ([\text{SA}' \llbracket \text{I go where} \rrbracket_d] (x)(s))$

In (ii), *tōngcháng* binds both the situation variable s and the entity variable x . Because **SA'** encodes the choice function, x is just one place that sells wine in s . Quantifying over situation–entity pairs (x, s) is equivalent to quantifying over situations s such that s associates with a certain liquor store x in s , not all liquor stores in s . Therefore, (ii) indicates that in most situations the speaker will go one liquor store.

8 Conclusion

In this paper, I have proposed a question + dynamic meaning approach to Mandarin *wh*-conditionals. According to my analysis, a Mandarin conditional embeds two *wh*-questions and quantifies over entities introduced as drefs by *wh*-expressions. These drefs are retrieved from the dynamicized Hamblin sets denoted by the *wh*-questions. I also have shown that it has empirical advantages over the classical indefinite approach and the recent question + categorial meaning approach.

Besides accounting for *wh*-conditionals, retrieving the values of *wh*-drefs from a dynamicized Hamblin set also offers a novel way of deriving short answers to *wh*-questions. As discussed in Section 4.3, the values of *wh*-drefs introduced in a *wh*-question precisely form a set of possible short answers to the question. This way of deriving short answers sheds light on a longstanding challenge for Hamblin Semantics. In particular, it has been argued that Hamblin Semantics cannot capture short answers, since it assumes that the meaning of a *wh*-question is the set of its possible propositional answers (Zimmermann 1985; Groenendijk & Stokhof 1989; Xiang 2020a; a.o.). Nevertheless, the dynamic upgrade proposed in this paper reveals that short answers can in fact be derived from propositional answers if there is more structure in a proposition. As a consequence, Hamblin Semantics with a dynamic upgrade can also handle phenomena that call for the use of short answers, such as free relatives and quantificational variability involving embedded questions (Jacobson 1995; Caponigro 2003; Cremers 2018; Xiang 2020a; a.o.). These phenomena are previously thought to be beyond the reach of Hamblin Semantics, but they can now be reunited with their interrogative kin in terms of their amenability to a Hamblin treatment.

A Formal analysis

The formal analysis demonstrates how the dynamic Hamblin Semantics is compositionally built. Roughly speaking, I extend the basic dynamic composition to an alternative-friendly dynamic composition in the same way as Hamblin (1973), Kratzer & Shimoyama (2002) and Shimoyama (2006) upgrade the basic compositional semantics to the compositional alternative semantics.

A.1 Type

Basic types Our basic types include individuals (type e), truth values ($t ::= \{0, 1\}$), possible worlds (type s) and lists (type σ). Constructed types take one of the following forms, where a and b are any two types:

- $a \rightarrow b$, the type of a function from a -type elements to b -type elements;
- $\{a\}$, the type of a set containing objects of type a ;
- $a \times b$, the type of the pair consisting of an a -type element and a b -type element.

Type abbreviation For readability, I define the following type abbreviations:

- $\mathbf{t} :: s \rightarrow (\sigma \times \sigma) \rightarrow (\sigma \times \sigma) \rightarrow t$, for dynamic propositions (i.e., a dynamic proposition is an intensional context change potential);

- $\mathbf{e} := (e \rightarrow \mathbf{t}) \rightarrow \mathbf{t}$, for dynamic individuals or dynamic generalized quantifiers that have base type e , take scope over dynamic propositions of type \mathbf{t} , and return type \mathbf{t} .

A.2 The basic dynamic fragment

Predicates

Expression	Meaning	Type
$\llbracket \text{see} \rrbracket_d$	$\lambda x \lambda y \lambda w \lambda i \lambda j. \text{see}_w(x)(y) \wedge i = j$	$e \rightarrow e \rightarrow \mathbf{t}$
$\llbracket \text{win} \rrbracket_d$	$\lambda x \lambda w \lambda i \lambda j. \text{win}_w(x) \wedge i = j$	$e \rightarrow \mathbf{t}$

Nominals

Expression	Meaning	Type
$\llbracket \text{Ann} \rrbracket_d$	$\lambda P \lambda w \lambda i. P(a)(w)(\langle \top_i \cdot a, \perp_i \rangle)$	\mathbf{e}
$\llbracket [\text{Ann}]_F \rrbracket_d$	$\lambda P \lambda w \lambda i. P(a)(w)(\langle \top_i, \perp_i \cdot a \rangle)$	\mathbf{e}
$\llbracket \text{a boy} \rrbracket_d$	$\lambda P \lambda w \lambda i. \bigcup_{x \in \text{boy}_w} P(x)(w)(\langle \top_i \cdot x, \perp_i \rangle)$	\mathbf{e}
$\llbracket [\text{a boy}]_F \rrbracket_d$	$\lambda P \lambda w \lambda i. \bigcup_{x \in \text{boy}_w} P(x)(w)(\langle \top_i, \perp_i \cdot x \rangle)$	\mathbf{e}
$\llbracket \text{she}_0^\perp \rrbracket_d$	$\lambda P \lambda w \lambda i. P((\perp_i)_0)(w)(i)$	\mathbf{e}

A few notes:

- An info-state consists of two lists. Which list is extended by a dref introducer depends on whether the dref introducer bears the primary focus or not.
- Pronouns are double indexed: the superscript \perp/\top determines which list in an info-state i is taken and the subscript determines which entity is picked out from a list. For instance, given an input info-state i , $\llbracket \text{she}_0^\perp \rrbracket_d$ picks out the individual in the last position of the bottom list. Specifically, for every list l , $(l)_n :=$ the member stored in the $|l| - 1 - n$ -th position of l . For example, given that $l = [a_0, b_1, c_2]$, l_0 is c .

Sentential operator

Expression	Meaning	Type
\triangle	$\lambda \psi \lambda \phi \lambda w \lambda i \lambda j \exists k. \phi(w)(i)(k) \wedge \psi(w)(k)(j)$	$\mathbf{t} \rightarrow \mathbf{t} \rightarrow \mathbf{t}$

Scope (Hendriks 1993)

(109) Argument Raising

Let f be any function of type $\vec{a} \rightarrow e_n \rightarrow \vec{b} \rightarrow \mathbf{t}$. \vec{a} and \vec{b} are sequences of semantic types (of any number, including none). e_n is the n -th argument of type e .

Then $f^{\uparrow n}$ is a function of type $\vec{a} \rightarrow e_n \rightarrow \vec{b} \rightarrow \mathbf{t}$, where

$$f^{\uparrow n} := \lambda \vec{z} \lambda \beta \lambda \vec{y}. \beta (\lambda x. f(\vec{z})(x)(\vec{y}))$$

$$(110) \quad (\llbracket \text{saw} \rrbracket_d^{\uparrow_1})^{\uparrow_2} = \llbracket \text{saw} \rrbracket_d^{\uparrow_{(1,2)}} = \lambda\beta\lambda\beta'.\beta'(\lambda y.\beta(\lambda x.\llbracket \text{saw} \rrbracket_d(x)(y))) \quad (\text{Surface scope})$$

$$(111) \quad (\llbracket \text{saw} \rrbracket_d^{\uparrow_2})^{\uparrow_1} = \llbracket \text{saw} \rrbracket_d^{\uparrow_{(2,1)}} = \lambda\beta\lambda\beta'.\beta(\lambda x.\beta'(\lambda y.\llbracket \text{saw} \rrbracket_d(x)(y))) \quad (\text{Inverse scope})$$

Derivation (The basic case)

$$(112) \quad \begin{aligned} \llbracket \text{Ann saw [a boy]}_F \rrbracket_d &= \llbracket \text{saw} \rrbracket_d^{\uparrow_{(1,2)}} (\llbracket [\text{a boy}]_F \rrbracket_d) (\llbracket \text{Ann} \rrbracket_d) \\ &= \llbracket \text{Ann} \rrbracket_d (\lambda y. \llbracket [\text{a boy}]_F \rrbracket_d (\lambda x. \llbracket \text{saw} \rrbracket_d(x)(y))) \\ &= \lambda w \lambda i \lambda j \exists x. \text{boy}_w(x) \wedge \text{see}_w(x)(a) \wedge j = \langle \top_i \cdot a, \perp_i \cdot x \rangle \end{aligned}$$

A.3 Composition of question meaning

Wh-expressions

Expression	Meaning	Type
$\llbracket \text{who} \rrbracket_d^{w_0}$	$\{\lambda P \lambda w \lambda i. P(x)(w)(\langle \top_i, \perp \cdot x \rangle) \mid x \in \text{human}_{w_0}\}$	$\{\mathbf{e}\}$

Alternative-friendly composition

Combinator	Denotation	Type
η	$\eta(x) = \{x\}$	$a \rightarrow \{a\}$
\otimes	$Y \otimes X = \{f(x) \mid f \in Y \wedge x \in X\}$	$\{a \rightarrow b\} \rightarrow \{a\} \rightarrow \{b\}$

Derivation (The basic case)⁴⁸

$$(113) \quad \begin{aligned} \llbracket \text{who saw Ann} \rrbracket_d &= (\eta(\llbracket \text{saw} \rrbracket_d^{\uparrow_{(1,2)}}) \otimes \eta(\llbracket \text{Ann} \rrbracket_d)) \otimes \llbracket \text{who} \rrbracket_d \\ &= \{\llbracket \text{saw} \rrbracket_d^{\uparrow_{(1,2)}}(\llbracket \text{Ann} \rrbracket_d)\} \otimes \llbracket \text{who} \rrbracket_d \\ &= \{\llbracket \text{saw} \rrbracket_d^{\uparrow_{(1,2)}}(\llbracket \text{Ann} \rrbracket_d)(\beta) \mid \beta \in \llbracket \text{who} \rrbracket_d\} \\ &= \{\lambda w \lambda i \lambda j. \text{see}_w(a)(x) \wedge j = \langle \top_i \cdot a, \perp_i \cdot x \rangle \mid x \in \text{human}_{w_0}\} \end{aligned}$$

Derivation (Conjoining *wh*-questions and cross-sentential anaphora to *wh*-expressions)

$$(114) \quad \begin{aligned} \llbracket \text{who won and what score did she}_0^\perp \text{ get} \rrbracket_d \\ = \llbracket \text{who won} \rrbracket_d \otimes (\eta(\triangle) \otimes \llbracket \text{what score did she}_0^\perp \text{ get} \rrbracket_d) \end{aligned}$$

⁴⁸ In my proposal, a *wh*-expression denotes a set of dynamic GQs, but the set itself is not dynamic. Simon Charlow (p.c.) points out that a problem arises when we need to bind a variable inside the *wh*-expression, for instance, *which of his paintings*. How many paintings are included in the set denoted by the *wh*-expression depends on the value of the pronoun. However, the restriction of the alternatives (i.e., $x \in \text{human}_{w_0}$ in (113)) is not dynamic, so the value of the pronoun cannot be determined. One solution is to assume that *which* contributes a set of choice functions, which pick out one member from a set. Then, the denotation of *which of his paintings* can informally be represented as $\{f\{x \mid x \in \text{his paintings}\} \mid f \in \text{CH}\}$. The pronoun occurs inside the alternative set. Another solution is to dynamicize the H/K semantics with the use of Charlow's (to appear) dynamic alternative semantics, which makes alternative sets dynamic as well as has a minimal impact on the present composition.

$$\begin{aligned}
&= \{ \phi \triangle \psi \mid \phi \in \llbracket \text{who won} \rrbracket_d \wedge \psi \in \llbracket \text{what score did she}_0^\perp \text{ get} \rrbracket_d \} \\
&= \left\{ \llbracket \text{won} \rrbracket_d^{\uparrow_1}(\beta) \triangle \llbracket \text{get} \rrbracket_d^{\uparrow_{(1,2)}}(\beta')(\llbracket \text{she}_0^\perp \rrbracket_d) \mid \beta \in \llbracket \text{who} \rrbracket_d \wedge \beta' \in \llbracket \text{what score} \rrbracket_d \right\} \\
&= \left\{ \lambda w \lambda i \lambda j. \text{win}_w(x) \wedge \text{get}_w(y)(x) \wedge j = \langle \top_i, \perp_i \cdot x \cdot y \rangle \mid \begin{array}{l} x \in \text{hmn}_{w_0} \wedge \\ y \in \text{score}_{w_0} \end{array} \right\}
\end{aligned}$$

The retrieving operator SA

$$\begin{aligned}
(115) \quad \text{SA } \llbracket \text{who won} \rrbracket_d &= \lambda y \lambda w \lambda i \lambda j. [\text{Ans}_{w,i} \llbracket \text{who won} \rrbracket_d](w)(i)(j) \wedge \perp_j - \perp_i = y \\
&= \lambda y \lambda w \lambda i \lambda j \exists x \in \text{hmn}_{w_0}. \text{win}_w(x) \wedge j = \langle \top_i, \perp_i \cdot x \rangle \wedge \perp_j - \perp_i = y \wedge \\
&\quad [\text{Ans}_{w,i} \llbracket \text{who won} \rrbracket_d] = [\lambda w' \lambda i' \lambda j'. \text{win}_{w'}(x) \wedge j' = \langle \top_{i'}, \perp_{i'} \cdot x \rangle] \\
&= \lambda y \lambda i \lambda j \exists x \in \text{hmn}_{w_0}. \text{win}_w(x) \wedge j = \langle \top_i, \perp_i \cdot x \rangle \wedge (\perp_i \cdot x) - \perp_i = y \wedge \\
&\quad [\text{Ans}_{w,i} \llbracket \text{who won} \rrbracket_d] = [\lambda w' \lambda i' \lambda j'. \text{win}_{w'}(x) \wedge j' = \langle \top_{i'}, \perp_{i'} \cdot x \rangle] \\
&= \lambda y \lambda w \lambda i \lambda j \exists x \in \text{hmn}_{w_0}. \text{win}_w(x) \wedge j = \langle \top_i, \perp_i \cdot x \rangle \wedge x = y \wedge \\
&\quad [\text{Ans}_{w,i} \llbracket \text{who won} \rrbracket_d] = [\lambda w' \lambda i' \lambda j'. \text{win}_{w'}(x) \wedge j' = \langle \top_{i'}, \perp_{i'} \cdot x \rangle] \\
&= \lambda y \lambda w \lambda i \lambda j. \text{hmn}_{w_0}(y) \wedge \text{win}_w(y) \wedge j = \langle \top_i, \perp_i \cdot y \rangle \wedge \\
&\quad [\text{Ans}_{w,i} \llbracket \text{who won} \rrbracket_d] = [\lambda w' \lambda i' \lambda j'. \text{win}_{w'}(y) \wedge j' = \langle \top_{i'}, \perp_{i'} \cdot y \rangle]
\end{aligned}$$

Discussion The essence of the composition proposed here is along the line of Hamblin (1973), Kratzer & Shimoyama (2002) and Shimoyama (2006). The original version of Hamblin Semantics compose static meanings, which are trivially transformed into set denotations. Two alternative sets are composed via the pointwise functional application. In the dynamic Hamblin Semantics, any dynamic meaning can be mapped to the corresponding set denotation via the function η , and the pointwise functional application is embodied by the function \otimes . The present proposal illustrates an ‘in-situ’ approach to composition, i.e., *wh*-expressions do not take scope (cf. Karttunen 1977). Correspondingly, I use Hendriks’s proposal of scope taking, which does not require Quantifier Raising at LF, to combine dynamic meanings. As a result, the two modes of composition are easily combined together.⁴⁹

B Comparing with Dekker’s (1993) Existential Disclosure

Existential Disclosure defined by Dekker (1993), written as \mathbf{ED}_n^D (the superscript D is short for ‘Dekker’, whereas the subscript n), is defined based on the mechanism of dynamic binding. A concrete example is given in (116).

$$\begin{aligned}
(116) \quad \mathbf{ED}_1^D \llbracket [\text{a boy}]_1 \text{ won} \rrbracket_d &= \lambda y. \llbracket [\text{a boy}]_1 \text{ won} \rrbracket \triangle (\lambda w \lambda i \lambda j. (\perp_i)_{1-1} = y \wedge j = i) \\
&= \lambda y \lambda w \lambda i \lambda j \exists x. \text{boy}_w(x) \wedge \text{win}_w(x) \wedge x = y \wedge j = \langle \top_i, \perp_i \cdot x \rangle \\
&= \lambda y \lambda w \lambda i \lambda j. \text{boy}_w(y) \wedge \text{win}_w(y) \wedge j = \langle \top_i, \perp_i \cdot y \rangle
\end{aligned}$$

⁴⁹ In addition to the present ‘in-situ’ composition, the dynamic Hamblin Semantics can also be established via the scope taking of alternative sets, which is facilitated by monads. See Charlow (2014, to appear) for the details.

\mathbf{ED}_1^p takes the meaning of *a boy won* and conjoins it with a dynamic proposition expressing an equation. $(\perp_i)_{1-1} (= (\perp_i)_0)$ refers to the index 1 borne by the indefinite and picks up the dref introduced by the indefinite. y is a free variable. Then, we obtain a dynamic predicate by abstracting over y .

In fact, \mathbf{ED}_n^p can also be exploited to retrieve drefs introduced by *wh*-expressions. The definition of the **SA** operator is revised as in (117).

$$\begin{aligned}
(117) \quad \mathbf{SA}'[\dots wh_1 \dots wh_n \dots]_d &:= \mathbf{ED}_{1, \dots, n}^p \left(\mathbf{Ans}(Q) \right) \\
&= \lambda x_1 \dots \lambda x_n \lambda w \lambda i. \left[\mathbf{Ans}_{w,i}(Q) \triangle \left(\lambda w \lambda i' \lambda j'. \left[\begin{array}{l} (\perp_j)_{n-1} = x_1 \wedge \dots \wedge \\ (\perp_j)_{n-n} = x_n \wedge j' = i' \end{array} \right] \right) \right] (w)(i) \\
&= \lambda x_1 \dots \lambda x_n \lambda w \lambda i \lambda j. [\mathbf{Ans}_{w,i}(Q)](w)(i)(j) \wedge (\perp_j)_{n-1} = x_1 \wedge \dots \wedge (\perp_j)_{n-n} = x_n
\end{aligned}$$

SA' retrieves drefs introduced by *wh*-expressions by referring to the indices of the *wh*-expressions. Suppose that there are n *wh*-expressions in the question. Each of them introduces a dref, which is added to the bottom list. Given the extended bottom list, the numbers in the set $\{n - n' \mid n' \in \{1, \dots, n\}\}$ indicate the positions on the list that store the relevant drefs. For concreteness, when a multiple-*wh* question has a single-pair reading (see Dayal 1996), each dynamic proposition in the set it denotes is associated with multiple drefs introduced by *wh*-expressions, as shown in (118).

$$\begin{aligned}
(118) \quad \llbracket [\text{which person}]_1 \text{ ordered what}_2 \rrbracket_d \\
= \left\{ \lambda w \lambda i \lambda j. \text{order}_w(y)(x) \wedge j = \langle \top_i, \perp_i \cdot x \cdot y \rangle \mid \text{hmn}_{w_0}(x) \wedge \text{thg}_{w_0}(y) \right\}
\end{aligned}$$

For each dynamic proposition in the set, the input bottom list is extended by adding two drefs x and y . That is, both *wh*-expressions introduce one dref in each dynamic proposition. In this case, **SA'** can target the drefs x and y via referring to the number of the *wh*-expressions. Specifically, we have two *wh*-expressions, so $(\perp \cdot x \cdot y)_{2-2} = y$ and $(\perp \cdot x \cdot y)_{2-1} = x$.

However, **SA'** is challenged when a multiple-*wh* question has a pair-list reading. In this case, each dynamic proposition in the question set has more newly added drefs than the number of *wh*-expressions. Recall the pair-list reading of *which person ordered what* in Section 6.3, repeated below.

$$\begin{aligned}
(119) \quad \sqcap \llbracket [\text{which person}]_1 \text{ ordered what}^2 \rrbracket_d \\
= \left\{ \lambda w \lambda i \lambda j. \left[\begin{array}{l} \text{order}_w(y_1)(a) \wedge \text{turn}_w(y_2)(e) \\ \wedge j = \langle \top_i, \perp_i \cdot a \cdot y_1 \cdot e \cdot y_2 \rangle \end{array} \right] \mid y_1, y_2 \in \{s, b\} \right\}
\end{aligned}$$

In this example, the *wh*-question contains two *wh*-expressions, but each dynamic proposition in the resulting set involves four novel drefs. In the present analysis of the pair-list reading, how many drefs are introduced by *wh*-expressions depends on the size of the alternative set denoted by the subject *wh*-expression. In (119), this set contains two members, like a and e , which are both correlated with a dref introduced by *what*. Therefore, the input bottom list is extended by adding two pairs consisting of a person and a dish. As a consequence, **SA'** cannot target all the drefs introduced in (119) by simply referring to the two *wh*-expressions. In order to handle this problem, we have to assume a more complicated reference system. I

leave this issue open for future study.

By contrast, **SA**, defined in Section 4.3, is built on **ED**, which uses the subtraction of lists to get a list only containing novel drefs. This derivational process does not refer to the drefs introduced by *wh*-expressions and hence does not run into the same problem as **ED**_n^p.

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