Mandarin *wh*-conditionals: A dynamic question approach

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Abstract

Mandarin has a special construction widely known as a '*wh*-conditional', in which both the antecedent clause and the consequent clause are *wh*-clauses. *Wh*-conditionals are of interest to linguists because the *wh*-expressions in a *wh*-conditional must co-refer. How to make sense of the fusion of a conditional and two *wh*-clauses, as well as the nature of the co-reference relation, have been long-standing issues. Two competing approaches have been advanced to shed light on *wh*-conditionals: the indefinite approach (Cheng and Huang 1996; Chierchia 2000; a.o.), which treats *wh*-expressions as indefinites that exhibit dynamic potentials, and the question-categorial 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 have unique advantages each. The goal of this paper is to devise an alternative approach that borrows insights from these two approaches but advoids their shortcomings. On the 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

Crosslinguistically, *wh*-expressions are not used as anaphors. For example, (1) does not mean 'Ann knows who$_1$ arrived late and they$_1$ 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 are functionally related. I will turn to this kind of *wh*-conditional 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 by Cheng and Huang (1996) and further developed by Lin (1996, 1999), Tsai (1999), Chierchia (2000), Pan and Jiang (2015), and others, 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. These 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 a contextually provided accessibility relation between possible worlds.

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

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 and 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. **Rúgǔo** shéi zhǎodào le, shéi jiù shì zui
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 and Jiang 2015)

However, according to Cheng and Huang (1996), the occurrence of *rúgǔo* 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 my examples.

[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 and Huang (1996) and assume that a covert necessity modal is involved.

tional operator, so they must co-refer. Thus, 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 appear in their interrogative uses rather than as 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, drawing on Hamblin-Karttunen semantics and partition semantics, and adopt a categorial approach (Hausser and Zaefferer 1979), which treats questions as sets of possible *short* answers, i.e., non-sentential constituents matching parts of speech of *wh*-expressions. 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 from a combination of 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, one overlooked by previous studies taking a question-based approach—

[4] Following Karttunen (1977), Liu and Xiang both assume that a *wh*-expression lexically denotes 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 the following case: given ten situations where a person wins, only in two situations does the winner pay (Cheng and Huang 1996). This shows that the quantification given by *hěnshǎojiàn* 'seldom' only cares about situations in which a person wins, rather than all situations.

(i) Hěnshǎojiàn, 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 the following scenario: suppose we have 100 situations in total and only in ten of them is there a person who wins; then the winner pays in *all* of these ten situations. Intuitively, the scenario falsifies (i). However, this 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 Dayal's (1997) discussion on the quantificational variability of *ever*-free relatives).

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

the dynamic potential of these expressions. As demonstrated in (6), the interrogative *shéi* 'who' supports cross-sentential anaphora (Comorovski 1996; van Rooy 1998; Aloni and van Rooy 2002; Haida 2007; Murray 2010; Dotlačil and Roelofsen 2018; a.o.), which has been standardly used to diagnose dref introduction since Karttunen (1976).[7] Intuitively, *shéi* introduces alternative people as drefs. In (6), there 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 term 'wh-*drefs*', which refers to drefs introduced by *wh*-expressions.

(6) Shéi^1 shū-le? Wǒmēn yào tā$_1$ 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 dynamicity 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 'dynamic question' approach. Since the dynamic essence can replace the categorial treatment of questions, the resulting account does not run into compositional issues found in the categorial question approach.

The dynamic question approach advanced in this paper involves the development of the dynamicization of Hamblin semantics (Hamblin 1973; Kratzer and 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 shown in (7). The alternatives evoked by *who* are set in SMALL CAPS; 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 $\xrightarrow{wh\text{-dref}}$ ann
Answer in w_2: BOB loses $\xrightarrow{wh\text{-dref}}$ bob
Answer in w_3: CLEO loses $\xrightarrow{wh\text{-dref}}$ 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

[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 and Law 2016) follow Hamblin semantics. They have argued that the composition mechanism assumed in Hamblin semantics can handle a wider range of phenomena.

this sense, the interrogative *wh*-expression is 'replaced' with a variable, ready to be bound.

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

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: as we will see, it is 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 functions characterizing sets of entities introduced as *wh*-drefs. These functions can be mapped to the restrictor and the scope of the covert necessity modal governing the conditional. So, the meaning of (2) can be rendered as (9).

(9) $\text{NEC}_{x,w} \left\{ \begin{array}{ll} \text{Restrictor} & \left[\begin{array}{l} x \text{ is introduced as a dref by the first } \textit{who} \text{ and} \\ \text{the answer to } \textit{who loses} \text{ in } w \text{ is } [x \text{ loses}] \end{array} \right] \\ \text{Scope} & \left[\begin{array}{l} x \text{ is introduced as a dref by the second } \textit{who} \text{ and} \\ \text{the answer to } \textit{who pays} \text{ in } w \text{ is } [x \text{ pays}] \end{array} \right] \end{array} \right.$

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

As seen in (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 a 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 into a predicate meaning. Although the transformational 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 in Chierchia's 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 this retrieval 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 the Appendix.

2 Data

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

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

In Cheng and 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. They can therefore be bound by the quantificational operator of a conditional, as reviewed in Introduction. In this section, I present two phenomena that challenge the empirical foundation of the classical approach and show that the *wh*-expressions in a *wh*-conditional share key properties with interrogative ones.[9]

2.1.1 Certain *wh*-expressions forming *wh*-conditionals lack indefinite uses

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 seen in (10), *shěnme* 'what' is embedded in the antecedent of the conditional and receives an indefinite interpretation. Therefore, it is reasonable to assume that *wh*-expressions embedded in *wh*-conditionals are also indefinites.

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

However, 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 *wèishěnme* 'why', the manner *wh*-expression *zěnme* 'how', and a series of degree *wh*-expressions, like *dūoshǎo* 'how many', *dūodà* 'how big', *dūokuài* 'how fast', do not have an indefinite use, as in (11)–(13).[10]

(11) *Rǔgǔo Lǐbái wèishěnme bèi jiěgù, tā yídìng hùi lái gàosù 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.'

[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 only be interpreted as indefinites in the scope of the negation marker *méi* 'not'. Other indefinite use licensors, like conditionals, polar questions, and modals, cannot license the indefinite use of these *wh*-expressions.

(12) *Rúgǔo Lǐbái zěnme xiūhǎo-le chē, tā yídìng hùi hěn gāoxìng.
if Libai how fix-ASP car he must will very happy
Intended: 'If Libai fixed the car in some way, he must be very happy.'

(13) *Rǔgǔo Lǐbài diū-le dūoshǎo dōngxī, tā yídìng hùi lái gàosù 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.'

These *wh*-expressions may form *wh*-conditionals, however, as exemplified below.[11]

(14) Lǐbái wèishěnme bèi jiěgù, Dùfǔ jiù wèishěnme 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 zěnme xiū chē, Dùfǔ jiù zěnme xiū chē.
Libai how fix car Dufu then how fix car
'For every x, if x is the way that L. fixes cars, x is the way that D. fixes 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 food L. ate, x is the amount of food 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 that the *wh*-clauses in (14) and (16) are considered questions. *Wèishěnme* and *dūoshǎo* are question words, alongside many other *wh*-expressions.[12]

[11] In Mandarin, *wèishěnme* 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), *wèishěnme* 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 and Huang 1996; Liu 2016), but reason *zěnme* 'how come' and sentence-initial *wèishěnme* ' why' cannot (Huang 2018), as exemplified below.

(i) a. *Tā zěnme chídào, wǒ jiù zěnme chídào.
he how.come late I then how.come late

b. *Wèishěnme tā chídào, wèishěnme 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 is due to the high syntactic position of the relevant *wh*-expressions. Tsai (2008) has convincingly argued that *zěnme* and the sentence initial *wèishěnme* 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-gùo], [zhè-piān wénzhāng, shéi jiù lǎi 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 reason *zěnme* and sentence-initial *wèishěnme*.

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 crosslinguistically (Haida 2007; AnderBois 2012; Trukenbrodt 2013; 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 and Li 1993; Shi 1994; Li and Law 2016), as shown in (17), but not with an indefinite *wh*-expression, as shown in (18).

(17) a. Zhècì **shì** shěi 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 gifts only to her?'

(18) a. *Rúgǔo zhècì **shì** shéi shū-le, tā jiù yào qǐngkè.
if this.time SHI who lose-ASP he then must pay

b. *Rúgǔo Lǐbái **zhǐ** gěi shéi sòng-le lǐwù, nǐ jiù lái gàosù 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 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 gift 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

As we have seen above, the *wh*-expressions in a *wh*-conditional exhibit the properties of interrogative *wh*-expressions rather than indefinite *wh*-expressions. The most direct way of capturing this observation is to analyze a *wh*-conditional as a conditional connecting two *wh*-questions. However, such a question-based analysis could 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 categorial treatment of short answers to *wh*-questions. They propose that a *wh*-conditional contains two *wh*-questions and expresses a dependency between these 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 and Zaefferer 1979; von Stechow and Zimmerman 1984; Ginzburg and Sag 2000; Jacobson 2016; Sharvit and 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. $[\![\text{who lost the bet}]\!]^{w_0} = \lambda x \lambda w.\mathsf{human}_{w_0}(x) \wedge \mathsf{lose.bet}_w(x)$
b. $[\![\text{who will pay}]\!]^{w_0} = \lambda x \lambda w.\mathsf{human}_{w_0}(x) \wedge \mathsf{pay}_w(x)$

Given a world w, the short answers to these questions in w are the individuals who lose the bet in w and those who pay in w. With the short answers in hand, the representation in (23) can be derived.[13]

Moreover, Zimmermann (1985) and Groenendijk and 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 and 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 and Liu both assume that the question meaning involves a component that represents a functional meaning, as we see in (24-a) and (24-b).[14]

[13] Both Xiang (2016, 2020a) and Liu (2016, 2017) syncategorematically assign meaning postulates to *wh*-conditionals, rather than categorematically deriving the meaning of *wh*-conditionals based on that of ordinary conditionals. This kind of treatment does not explain the connection between these two types of conditionals.

[14] The structured meaning approach to questions (von Stechow 1991) as well have been exploited to derive short answers in the literature (Krifka 2001a; Weir 2018). Liu's (2016) formal analysis is 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, and this pair 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.

Although the categorial approach does indeed offer a sound solution for the two questions in (21), this approach has its limits (Groenendijk and Stokhof 1989; George 2011). These limitations are inherited in turn by the categorial question approach to *wh*-conditionals. The following subsections discuss three empirical phenomena that are not fully covered by the categorial question approach.

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

The fact that a *wh*-conditional can contain two conjunctions of *wh*-clauses is rarely singled out in the literature, because it is in keeping with the expectations of the classical indefinite approach. However, it challenges the question-based approach, for the derivation of short answers to conjunctions of *wh*-questions poses difficulties. Consider (25) and (26), which contain conjunction(s) of *wh*-clauses. Note that in Mandarin, clausal conjunction is not marked by an overt conjunctive. Note also that the second *wh*-conjunct in (26) has a null object, which can be understood as a null pronoun pro referring to *shěnme*.[15]

(25) Nǐ [chī **shěnme** cài], tā [hē **shěnme** jiǔ], wǒ jiù yào [chī **shěnme** cài], [hē
you eat what dish he drink what wine I then must eat what dish drink
shěnme 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 drink.'

(26) [**Nǎ-gè** nánháir qūe **shěnme**], [**nǎ-gè** nǚháir zhènghào yòu yǒu pro],
which-CL boy lack what which-CL girl happen just have it
nǎ-gè nánháir jiù hùi gēn **nǎ-gè** nǚháir jiè **shěnme**.
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 the *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 semantically derived.

Across languages, the conjunction of *wh*-clauses has been a long-standing problem for the categorial approach (Groenendijk and 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, studies pursuing a categorial approach have proposed various ways to shift the categorial meanings of *wh*-clauses to the corresponding propositional meanings (Groenendijk

[15] Note that pro is bound by *shěnme*, even though it is 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.

and Stokhof 1984, 1989; Berman 1991). Let me take Berman's (1991, p. 226) proposal for concreteness. Following him, we define an operator π mapping a function R, which may have a sequence of arguments, to a set of propositions, as in (27).

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

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) $[\![\text{Q}_1 \text{ and } \text{Q}_2]\!] = \{\, p \wedge q \mid p \in [\![\text{Q}_1]\!], q \in [\![\text{Q}_2]\!] \,\}$

However, this analysis 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 no longer possible to track possible short answers to the *wh*-question, as argued in Zimmermann (1985) and Groenendijk and 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 generate 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 mapping question meanings to propositions, as discussed in Groenendijk and Stokhof (1989). In (25), the conjunction of *wh*-clauses in the antecedent clause is analyzed as follows. In the categorial approach, both *wh*-clauses denote predicates of type $e \to s \to t$. Therefore, $\mathcal{Q}$ is a function of type $(e \to s \to t) \to (s \to t)$, 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) $\lambda \mathcal{Q}. \mathcal{Q} \overbrace{([\![\text{you ate what dish}]\!]^{w_0})}^{\lambda x \lambda w. \text{dish}_{w_0}(x) \wedge \text{eat}_w(x)([\![\text{you}]\!])} \wedge \mathcal{Q} \underbrace{([\![\text{he drank what wine}]\!]^{w_0})}_{\lambda x \lambda w. \text{wine}_{w_0}(x) \wedge \text{drink}(x)([\![\text{he}]\!])}$

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 that contains them.[17] In particular, the meaning of (25) can be derived as follows.

(30) (Q_1 = 'you ate what dish', Q_2 = 'he drunk what wine', Q_3 = 'I ate what dish', Q_3 = 'I drunk what wine')

$[\lambda \mathcal{Q}. \mathcal{Q}([\![\text{Q}_1]\!]) \wedge \mathcal{Q}([\![\text{Q}_2]\!])]\ \lambda P. [[\lambda \mathcal{Q}. \mathcal{Q}([\![\text{Q}_3]\!]) \wedge \mathcal{Q}([\![\text{Q}_4]\!])]\ \lambda P'. [\![\text{jiù}]\!](P')(P)]$

$= [\lambda \mathcal{Q}. \mathcal{Q}([\![\text{Q}_1]\!]) \wedge \mathcal{Q}([\![\text{Q}_2]\!])]\ \lambda P. [\![\text{jiù}]\!]([\![\text{Q}_3]\!])(P) \wedge [\![\text{jiù}]\!]([\![\text{Q}_4]\!])(P)$

$= [\![\text{jiù}]\!]([\![\text{Q}_3]\!])([\![\text{Q}_1]\!]) \wedge [\![\text{jiù}]\!]([\![\text{Q}_4]\!])([\![\text{Q}_1]\!]) \wedge [\![\text{jiù}]\!]([\![\text{Q}_3]\!])([\![\text{Q}_2]\!]) \wedge [\![\text{jiù}]\!]([\![\text{Q}_4]\!])([\![\text{Q}_2]\!])$

[16] Jacobson (2016) suggests that *wh*-questions should be coordinated at the speech act level (Krifka 2001b), but it's not clear whether short answers are 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.

As a result, we get a conjunction of four *wh*-conditionals. None of these *wh*-conditionals contain conjunction of *wh*-clauses. Accordingly, the resulting reading is equivalent to (31).[18] However, this reading is not available for (25).

(31) Nǐ chī **shěnme** cài, wǒ jiù yào chī **shěnme** cài; nǐ chī **shěnme** cài, wǒ jiù yào hē **shěnme** jiǔ; tā hē **shěnme** jiǔ, wǒ jiù yào chī **shěnme** cài; tā hē **shěnme** jiǔ, wǒ jiù yào hē **shěnme** jiǔ.
you eat what dish I then want eat what dish you eat what dish I then want drink what wine he drink what wine I then want eat what dish he 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 corresponding wine; if he drinks some kind of wine, I eat the corresponding 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 Q yielded by lifting cannot 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. $[\![\text{which boy lacks what}]\!] = \lambda x \lambda y \lambda w.\text{boy}_{w_0}(x) \wedge \text{thing}_{w_0}(x) \wedge \text{lack}_w(y)(x)$
b. $[\![\text{which girl has } \texttt{pro}]\!] = \lambda z \lambda w.\text{girl}_{w_0}(z) \wedge \text{have}_w([\![\texttt{pro}]\!])(z)$

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

2.2.2 Conditionals cannot embed A-*not*-A questions

Accounts of *wh*-conditionals couched in the categorial question approach are confronted with a potential over-generation problem. The central spirit of such accounts is that *wh*-conditionals express a question dependency with respect to short answers. *Yes-no* questions

[18] Note that the *wh*-expressions in (31) range over kinds; thus, *shěnme cài* means 'what kind of dish', while *shěnme jiǔ* means 'what kind of wine'. See Lin (1999) for a detailed discussion of the domain of *shěnme*.

[19] See Xiang (2020, fn.34) for a potential solution to this issue.

[20] Although the existing analyses cannot generate correct short answers to conjunctions of *wh*-clauses, re-formulating 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 $\lambda x.\text{eat}(x)(\text{a})$. 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 $\lambda x \lambda y \lambda z.\text{buy}(y)(z) \wedge \text{happy}(x)$. 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 with respect to other aspects of grammar, in particular, binding. That is, a *wh*-expression could be bound as a pronoun. This is an unwelcome prediction.

also admit short answers. In the categorial approach, the meaning of polar questions is normally modeled as a function from functions to propositions (Groenendijk and Stokhof 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* corresponds to the function $\lambda p.W-p$ (where W is the set of all the possible worlds).

(33) $[\![\text{Did Ann cry}]\!] = \lambda f.f\,(\lambda w.\text{cry}_w(\text{a}))$

The categorial question 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 then often called 'A-*not*-A questions'.[21] The conditional in (34), which involves two polar questions in the A-*not*-A form, is predicted to be allowed, though in fact it is not acceptable.

(34) *Lǐbái kū-méi-kū, Dùfǔ jiù kū-méi-kū.
Libai cry-not-cry Dufu then cry-not-cry
Intended: 'If L. cried, then D. cried, and if L. didn't cry, then D. didn't cry.'

The intended meaning would be explained in this way: the short answer to the question *Libai cry-not-cry* is the same as the short answer to the question *Dufu cry-not-cry*. However, A-*not*-A questions cannot be part of a conditional, as pointed out by Cheng and Huang (1996).

Note that the unacceptability of (34) doesn't mean that the *wh*-clauses in a *wh*-conditional cannot be construed as interrogative constructions. Not even all question-embedding verbs can embed all types of questions. This holds for English as well. 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, Mandarin 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 question cannot occur 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 seen 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 that 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 it is Libai or Dufu who is late, he will be penalized.'

In fact, the analysis of alternative questions is debated. Biezma and Rawlins (2012), Erlewine (2014), and Li and Law (2016) analyze English and Mandarin alternative questions in the same way as *wh*-questions, but Han and Romero (2004) 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. These phenomena indicate that alternative questions might be different from *wh*-questions in their structure and meaning. An argument built on alternative questions may not necessarily challenge or support an account for *wh*-conditionals. Based on this concern, this paper will not

2.3 Summary

The phenomena presented in this section lead to a dilemma. On one hand, *wh*-conditionals share key 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 laid out 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: crosslinguistically, they can support cross-sentential anaphora, like indefinites (e.g. 'A^1 boy was late. He$_1$ arrived at 10.'). Consider (35).

(35) [Which boy]^1 was late? When did he$_1$ arrive?

In order to answer this sequence of questions, the addressee must name the boy who was late and specify the time when he arrived. Thus, 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; Aloni and van Rooy 2002; Haida 2007; Murray 2010; Dotlačil and Roelofsen 2018, 2020).

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 in the first clause co-varies with the *wh*-expression *shěnme* in the second clause.[23]

(36) [**Nǎ-gè** nánháir qūe **shěnme**^{1}], [**nǎ-gè** nǚháir zhènghào yòu yǒu pro$_1$],
which-CL boy lack what which-CL girl happen YOU have it
nǎ-gè nánháir jiù hùi gēn **nǎ-gè** nǚháir jiè **shěnme**.
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 a pronoun in the consequent clause of a conditional is referentially dependent on an indefinite in the antecedent clause; for example, 'If a^1 farmer owns a^2 donkey, he$_1$ feeds it$_2$ very well'. However, for *wh*-conditionals with co-indexed *wh*-expressions, it is not easy to construct 'donkey' anaphora.

include an account for the unacceptability of (i) and leave it for future research.

[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.

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

(37) Shéi^1 yǎng-le māo, shéi^1 jiù yào gěi tā$_1$-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, even if not 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 dad 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 discussed before, here 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 to the child's dad. Even though this kind of *wh*-conditional 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 is functionally correlated with the one in the antecedent. That is, the *wh*-conditional cannot be true if one kid is late and another kid's father is penalized. To my knowledge, Hua (2000) is the first to investigate this 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) $\mathsf{NEC}_{x,w}\left[\mathsf{kid}_w(x) \wedge \mathsf{late}_w(x)\right]: \left(\mathsf{father}_w(f(x)) \wedge \mathsf{penlz}_w(f(x))\right)$

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.

It is fair to ask where the functional dependency observed in this kind of *wh*-conditional is coming 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 goes 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)(p. 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 obtained. For example, in (41) and (42), the pronouns in the consequent clauses clearly refer to the *wh*-expressions in the antecedent clauses.

(41) Nǎ-gè^1 háizi fàn-le cuò, nǎ-gè^2 jiāzhǎng jiù huì pīpíng tā$_1$.
which-CL kid make-ASP mistaje 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-gè^1 háizì yǎng-le māo, nǎ-gè^2 jiāzhǎng jiù yào dài tā$_1$-de māo jiēzhòngyìmiáo.
which-CL kid keep-ASP cat which-CL parent then must bring her-DE cat vaccinate
'For every kid x, if x has a cat, x's parent is the one who brings x's cat to be vaccinated.'

In short, the dynamic potentials of *wh*-expressions motivate a dynamic treatment of these expressions, i.e., they introduce drefs. Drawing on the feature 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 categorial question approach, while at the same time avoiding the problems they raised.

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 and Shimoyama 2002; Shimoyama 2006). 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). *Wh*-questions denote sets of dynamic sentence meanings, as in (44), which are possible propositional answers to the question.[27]

(43) $[\![\text{which boy}]\!]_d = \{[\![\text{ALEX}]\!]_d, [\![\text{BOB}]\!]_d, ...\}$

(44) $[\![\text{which boy was late}]\!]_d = \{[\![\text{ALEX was late}]\!]_d, [\![\text{BOB was late}]\!]_d, ...\}$

25 The two ways of determining functional dependencies are close to Barker's (1995) distinction between 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 *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 $[\![\cdot]\!]$ maps a linguistic expression to a static meaning, $[\![\cdot]\!]_d$ maps a linguistic expression to a dynamic meaning.

Each propositional answer is associated with a dref introduced by *which boy*. These drefs are retrievable in dynamic semantics. Retrieving these drefs leads to possible short answers to the 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 dynamic question 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]

$$\left\langle \underset{\text{top list}}{\begin{array}{ccc} 0 & 1 & 2 \\ \hline \multicolumn{1}{|c|}{\mathrm{a}} & \multicolumn{1}{c|}{\mathrm{b}} & \multicolumn{1}{c|}{\mathrm{c}} \\ \hline \end{array}}\ ,\ \underset{\text{bottom list}}{\begin{array}{ccc} 0 & 1 & 2 \\ \hline \multicolumn{1}{|c|}{\mathrm{e}} & \multicolumn{1}{c|}{\mathrm{h}} & \multicolumn{1}{c|}{\mathrm{g}} \\ \hline \end{array}} \right\rangle$$

Such an info-state can model the information status of drefs. In this paper, I use 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), for example. In B's utterance, the subject *Ann* is the topic and the object *a book* that corresponds to *what* is taken to bear the primary focus. Consequently, the dref introduced by the subject is added to the top list, while the dref introduced by the object is added to the 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]$_{\text{T}}$ bought [a book]$_{\text{F}}$.

(46) $[\![(45)]\!]_d = \lambda w \lambda i \lambda j \exists x.\mathrm{bk}_w(x) \wedge \mathrm{buy}_w(x)(\mathrm{a}) \wedge j = \langle \top_i \cdot \mathrm{a},\ \bot_i \cdot x \rangle$

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.

[28] Hardt (1999) proposes an alternative way to model the distinction between 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 its essence. I use lists because the distinction between drefs is visually more explicit.

[29] Independent motivation for the creation of two sublists stems from many crosslinguistic phenomena, including grammatical centering in Kalaallisut, reference to tense in English, and null pronouns and aspect particles in Mandarin (Bittner 2014).

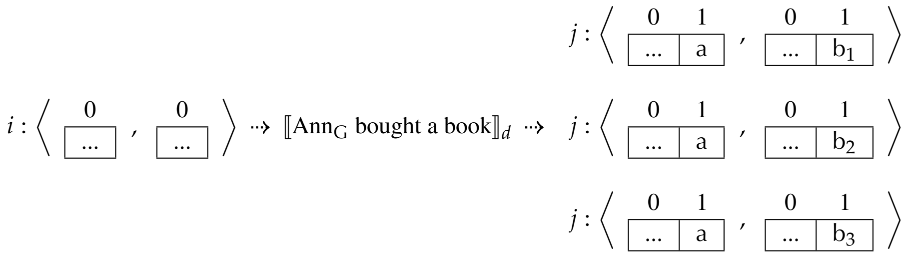
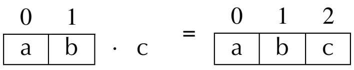
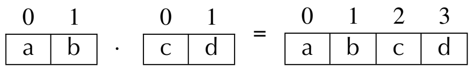


Figure 1: Dynamic update of the sentence in (46)

2. i and j are variables over info-states (i.e. pairs of lists).
3. $\top$ and $\bot$ are projection functions that map a list pair i to its top list ($\top_i$) and bottom list ($\bot_i$), respectively.
4. The operator $\cdot$ appends an entity to a list, as visualized in the picture on the left. It also concatenates the two lists, as visualized in the picture on the right.





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 of type $\omega \to (\sigma \times \sigma) \to (\sigma \times \sigma) \to t$, abbreviated as $\mathbf{t}$.

To interpret (46), we feed it an input info-state; 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 our question semantics. In the original Hamblin semantics, the meaning of a question is a set of its possible propositional answers (Hamblin 1973, Kratzer and 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. For example, *who* denotes a set of human entities, such as the set of men $\{ [\![\text{BOB}]\!], [\![\text{SAM}]\!] \}$. This alternative set 'expands' as it undergoes a suitable compositional process and 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)
$$[\![\text{who saw Ann}]\!] = \left\{ \begin{array}{l} [\![\text{BOB saw Ann}]\!], \\ [\![\text{SAM saw Ann}]\!] \end{array} \right\} \rightsquigarrow \text{Dynamicization} \rightsquigarrow [\![\text{who saw Ann}]\!]_d = \left\{ \begin{array}{l} [\![\text{BOB saw Ann}]\!]_d, \\ [\![\text{SAM saw Ann}]\!]_d \end{array} \right\}$$

[30] This paper will not discuss the semantic contribution of focus, except in Section 6.2, where I briefly show how a 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 $\mathbf{e} ::= (e \to \mathbf{t}) \to \mathbf{t}$), as shown in (48), instead of a set of static individuals. Each dynamic individual introduces a static individual (b, s) as a dref.

(48) $$[\![\text{who}]\!]_d = \{[\![\text{Bob}]\!]_d, [\![\text{Sam}]\!]_d\} = \{\overbrace{\lambda P \lambda w \lambda i \lambda j. P(x) \wedge j = \langle \top_i, \bot_i \cdot x\rangle}^{\text{dynamic individual}} \,|\, x \in \{\text{b}, \text{s}\}\}$$

The status of *wh*-drefs As assumed in the last subsection, info-states are pairs of lists. I use these pairs to distinguish *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 element 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, but not the primary one. This difference in information status has been used in Tomioka (2007) to account for the fact that the co-occurrence of a *wh*-expression and another primary focus leads to reduced acceptability.[31] In light of this focus property of *wh*-expressions, they are assumed to introduce drefs to the bottom list in the dynamic model. By contrast, non-*wh* expressions introduce drefs to the top list.[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) $$\begin{aligned}[\![\text{who saw Ann}]\!]_d &= \{[\![\text{Bob saw Ann}]\!]_d,\ [\![\text{Sam saw Ann}]\!]_d\}\\ &= \{\lambda w \lambda i \lambda j.\text{see}_w(\text{a})(x) \wedge j = \langle \top_i \cdot \text{a},\ \bot_i \cdot x\rangle \mid x \in \{\text{b}, \text{s}\}\}\end{aligned}$$

The intuition behind 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)

[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]$_{\text{CT}}$ eat?

In the literature, *Ann* is called a 'contrastive topic', which generates a set of questions not uttered explicitly (Büring 2003; Tomioka 2010; Constant 2014; Krifka 2017). Although it bears an accent, its semantic contribution is not the same as focused elements.

[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 and Erlewine 2018; Dong 2018; Uegaki 2018). The other view is that *wh*-expressions inherently denote alternative sets, so that it is not necessary to assume that they evoke focus alternatives (Ishihara 2003; Eckardt 2007; Li and 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.

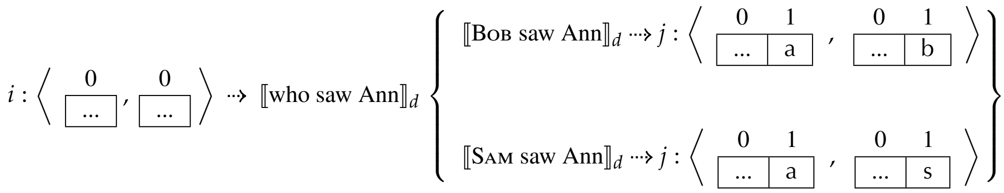


Figure 2: Dynamic update of the *wh*-question in (49)

updates the input context and generates an output. The addressee has to select one such output to update the context. This mechanism follows the spirit of the discourse dynamics of questions proposed in Farkas and Bruce (2010).[33]

Composition The dynamic Hamblin semantics can be made compositional in the same way that the static Hamblin semantics can (Kratzer and 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.

(50)
$$\begin{aligned}[\![\text{who saw Ann}]\!]_d &= [\![\text{who}]\!]_d \circledast \left(\{[\![\text{saw}]\!]_d\} \circledast \{[\![\text{Ann}]\!]_d\} \right) \\ &= [\![\text{who}]\!]_d \circledast \{[\![\text{saw}]\!]_d \bullet [\![\text{Ann}]\!]_d\} \\ &= \{\ \beta \bullet [\![\text{saw}]\!]_d \bullet [\![\text{Ann}]\!]_d \mid \beta \in [\![\text{who}]\!]_d\} \\ &= \{\ [\![\text{Bob}]\!]_d \bullet [\![\text{saw}]\!]_d \bullet [\![\text{Ann}]\!]_d,\ [\![\text{Sam}]\!]_d \bullet [\![\text{saw}]\!]_d \bullet [\![\text{Ann}]\!]_d\ \}\end{aligned}$$

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

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: it is built from two known operations—Existential Disclosure and Answerhood Operator.

Existential Disclosure Drefs are retrievable in dynamic semantics. This property allows us to introduce a retrieval operator, which we define based 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

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

the present dynamic framework.[34] Notationally, $\lambda x_1, x_2, ..., x_n = \lambda x_1 \lambda x_2 ... \lambda x_n$, and e^n is a sequence of e-types of number n.

(52) a. $\mathbf{ED}^{\perp}(\phi) := \overbrace{\lambda x_1, x_2, ..., x_n}^{\text{values of drefs}} \underbrace{\lambda w \lambda i \lambda j. \phi(w)(i)(j) \wedge \perp_j - \perp_i = x_1 \cdot x_2 \cdot ... \cdot x_n}_{\text{dynamic proposition}}$

b. $\mathbf{ED}^{\top}(\phi) := \lambda x_1, x_2, ..., x_n \lambda w \lambda i \lambda j. \phi(w)(i)(j) \wedge \top_j - \top_i = x_1 \cdot x_2 \cdot ... \cdot x_n$

$\mathbf{ED} :: \mathbf{t} \to e^n \to \mathbf{t}$

$\mathbf{ED}^{\perp}(\phi)$ as a function characterizes a set of (sequences of) entities $(x_1, x_2, ..., x_n)$ 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 the outputs (i.e., $\perp_j - \perp_i$), yielding a list of the variables x_1, x_2, ..., x_n whose values must be associated with drefs in the outputs of ϕ; (iii) these variables are 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).

(53) $\mathbf{Ans}_{w,i}(Q) := \iota\phi \in Q$, such that

a. $\phi(w)(i)$ is dynamically true and

b. for all $\psi \in Q$, if $\psi(w)(i)$ is dynamically true, ϕ entails ψ w.r.t i.

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) $\phi(w)(i)$ is dynamically true iff $\exists j. \phi(w)(i)(j)$ is true.

(55) ϕ entails ψ w.r.t i iff $\forall j \forall w. \phi(w)(i)(j) \to \exists k. \psi(w)(j)(k)$.

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 are formed via the sum operation $\oplus$ (Link 1983). In dynamic Hamblin semantics, *wh*-drefs introduced by *who* may include singular individuals and their sums. Because of the existence oof the plural individual, I assume that the static properties and relations on which dynamic meanings are built are closed cumulatively. For example, given a

[34] Existential Disclosure as defined in Dekker (1993) is couched in Dynamic Montague Grammar (Groenendijk and 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. In most cases the two procedures give rise to the same result, but the present procedure has an advantage when retrieving values of *wh*-drefs in a multiple-*wh* question. A comparison of these two procedures 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 Existential Disclosure).

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

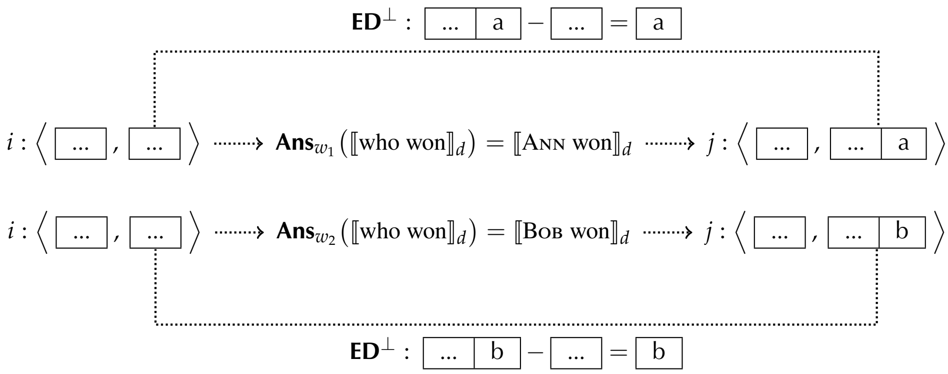


Figure 3: The process of retrieving values of *wh*-drefs

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 $\text{see}_w(x \oplus x')(y \oplus y')$.

(56) $[\![\text{who was late}]\!]_d = \{\lambda w \lambda i \lambda j.\text{late}_w(x) \wedge j = \langle \top_i,\ \bot_i \cdot x \rangle \mid x \in \{\text{a}, \text{b}, \text{a} \oplus \text{b}\}\}$
$= \{[\![\text{Ada was late}]\!]_d, [\![\text{Bob was late}]\!]_d, [\![\text{Ada and Bob were late}]\!]_d\}$

Applying **Ans** to the *wh*-question in (56) yields the maximally informative dynamic proposition ϕ relative a possible world w and an input info-state i; that is, 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 were both late in w_0, then $[\![\text{Ada and Bob were late}]\!]_d$ is maximally informative relative to w_0 and i. This dynamic proposition is the complete propositional answer to the question.

Combining ED with Ans 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(nn), b(ob)} and two possible worlds $\{w_1, w_2\}$. The *wh*-expression *who* denotes a set of dynamic individuals containing $[\![\text{Ann}]\!]_d$ and $[\![\text{Bob}]\!]_d$, 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 $[\![\text{Ann won}]\!]_d$ in w_1 and $[\![\text{Bob won}]\!]_d$ 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*. **ED**$^\perp$ applies to each of these complete answers 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 **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, **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) $\textbf{SA}(Q) := \textbf{ED}^\perp(\textbf{Ans}(Q))$ $\qquad\qquad$ $\textbf{SA} :: \{\textbf{t}\} \to e^n \to \textbf{t}$
$= \lambda x_1, x_2 ... x_n \lambda w \lambda i \lambda j. [\underbrace{\textbf{Ans}_{w,i}(Q)}_{\phi}](w)(i)(j) \wedge \bot_j - \bot_i = x_1 \cdot x_2 \cdot ... \cdot x_n$

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 won in w] is the complete answer to *who won* in w.

(58) $\left[\textbf{SA}\ [\![\text{who won}]\!]_d\right]$

$$= \lambda y \lambda w \lambda i \lambda j. \left[\textbf{Ans}_{w,i} [\![\text{who won}]\!]_d\right](w)(i)(j) \wedge \bot_j - \bot_i = y$$

$$= \lambda y \lambda w \lambda i \lambda j.\mathsf{human}_{w_0}(y) \wedge \mathsf{win}_w(y) \wedge j = \langle \top_i, \bot_i \cdot y \rangle \wedge \left[\textbf{Ans}_{w,i} [\![\text{who won}]\!]_d\right] = \left[\lambda w' \lambda i' \lambda j'.\mathsf{win}_{w'}(y) \wedge j' = \langle \top_{i'}, \bot_{i'} \cdot y \rangle\right]$$

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 the expression dynamically true are people who won in a possible world. Within the small model shown in Figure 3, these people would be Ann (relative to w_1) and Bob (relative to w_2). They furnish the two 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 we 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 as well as *a man* and *Ann* introduce drefs.

(59) <u>Who</u> asked <u>a man</u> to send <u>what</u> to <u>Ada</u>?

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 this background on the dynamics of *wh*-questions, we are ready to turn to the analysis of *wh*-conditionals. Section 5.1 presents our analysis for *wh*-conditionals. Section 5.2 demonstrates how this analysis is extended to *wh*-conditionals embedding conjunctions of *wh*-clauses. Section 5.3 explains why two A-*not*-A questions cannot be connected to form 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 postulate the following definition for a conditional without any overt modal or adverb.

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

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

Basic case In a *wh*-conditional, the restrictor 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) $\mathbf{NEC}_{x,w}\,\big[\,[\mathbf{SA}\ [\![\text{who loses}]\!]_d]\,(x)(w)\big] : \big(\,[\mathbf{SA}\ [\![\text{who pays}]\!]_d]\,(x)(w)\big)$

In prose: For every world w and entity x s.t. x is introduced as a dref by the first instance of *who* and [x loses] completely answers *Who loses* in w, x is introduced as a dref by the second instance of *who* and [x pays] completely answers *Who pays* in w.

In (62), **NEC** quantifies over the entities introduced as *wh*-drefs. For every x, [x loses] and [x 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. This 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 its 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-gè[1] háizi fàn-le cuò, nǎ-gè[2] jiāzhǎng jiù huì pīpíng tā_1.
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) $$\mathbf{NEC}_{x,w} \begin{cases} \text{Restrictor} & [\mathbf{SA}\ [\![\text{which kid makes a mistake}]\!]_d]\ (x)(w) \\ & = \lambda i \lambda j.\mathsf{kid}_{w_0}(x) \wedge \mathsf{mistake}_w(x) \wedge j = \langle \top_i, \bot_i \cdot x \rangle \\ \\ \text{Scope} & [\mathbf{SA}\ [\![\text{which parent scold him}_0^{\bot}]\!]_d]\ (f(x))(w) \\ & = \lambda i \lambda j.\mathsf{parent}_{w_0}(f(x)) \wedge \mathsf{scold}_w([\![\text{him}_0^{\bot}]\!]_d)(f(x)) \wedge \\ & \quad j = \langle \top_i, \bot_i \cdot f(x) \rangle \end{cases}$$

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 as in Figure 4: if Bob (b) makes a mistake (b is fed into the Restrictor), then his parent (f(b)) will criticize him (referring to b); if Eric (e) makes a mistake (e is fed into the Restrictor), then his parent (f(e)) will criticize him (referring to e).

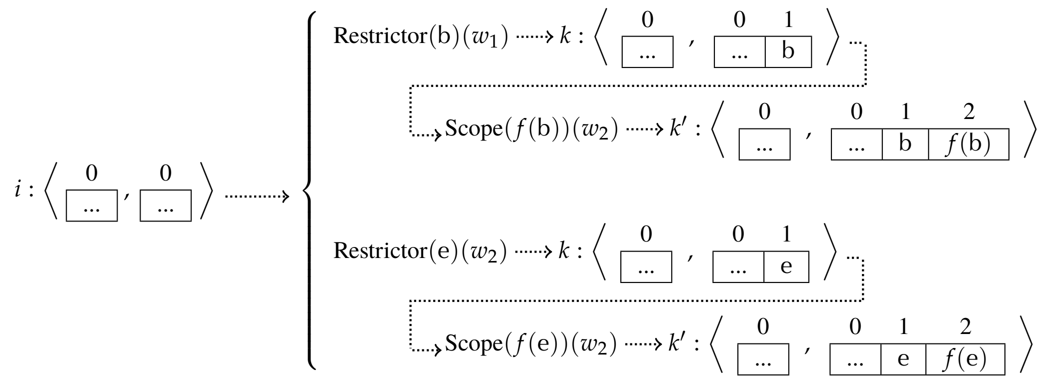


Figure 4: Sample updates involved in 'donkey' anaphora

The pronoun *him* bears two indices—the subscript 0 and the superscript $\bot$. This means 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 the 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 between 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 that the present analysis also resolve the problematic 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 directly extended to *wh*-conditionals embedding conjunctions of *wh*-clauses, like (66). The extension is given in (67).

(66) Nǐ [chī **shěnme** cài], tā [hē **shěnme** jiǔ], Lǐbái jiù yào [chī **shěnme** cài], [hē **shěnme** jiǔ].
you eat what dish he drink what wine Libai then must eat what dish 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 Libai want to eat and y is what Libai want to drink.'

(67) $$\textbf{must}_{\vec{x},w} \begin{cases} \text{Restrictor} & [\textbf{SA}\ [\![\text{you eat wh.dish and he drinks wh.wine}]\!]_d]\ (\vec{x})(w) \\ \text{Scope} & [\textbf{SA}\ [\![\text{Libai eat wh.dish and Libai drink wh.wine}]\!]_d]\ (\vec{x})(w) \end{cases}$$

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 the wine that he drinks in w, x_1 is the dish that Libai eats in w and x_2 is the wine that Libai drinks 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) $[\![\text{you eat wh.dish}]\!]_d = \{[\![\text{you eat }\textsc{salad}]\!]_d, [\![\text{you eat }\textsc{beans}]\!]_d\}$

(69) $[\![\text{he drinks wh.wine}]\!]_d = \{[\![\text{he drinks }\textsc{red.wine}]\!]_d, [\![\text{he drinks }\textsc{white.wine}]\!]_d\}$

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) $$\{\ \phi \triangle \psi \mid \phi \in [\![\text{you eat wh.dish}]\!]_d \wedge \psi \in [\![\text{he drinks wh.wine}]\!]_d\ \}$$
$$= \left\{ \begin{array}{l} [\![\text{you eat }\textsc{salad}]\!]_d \triangle [\![\text{he drks }\textsc{r.w.}]\!]_d, [\![\text{you eat }\textsc{beans}]\!]_d \triangle [\![\text{he drks w.w.}]\!]_d, \\ [\![\text{you eat }\textsc{salad}]\!]_d \triangle [\![\text{he drks w.w.}]\!]_d, [\![\text{you eat }\textsc{beans}]\!]_d \triangle [\![\text{he drks }\textsc{r.w.}]\!]_d \end{array} \right\}$$

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) $$\textbf{SA}(70) := \lambda x \lambda y \lambda w.\lambda i \lambda j.\big[\textbf{Ans}_{w,i}(70)\big](w)(i)(j) \wedge \bot_j - \bot_i = x \cdot y$$

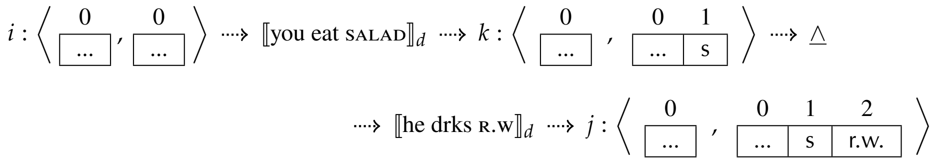


Figure 5: Context update of a dynamic conjunction

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 $\boxed{s \mid r.w}$. Correspondingly, the food–wine sequence $[s, r.w]$ and w_1 saturates the function in (71). Assembling the food–wine sequences retrieved relative to different worlds gives us a set of sequences. This set restricts the domain of **must** in (67). 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 deterministic values, which leads to a semantic/pragmatic defect when these are quantified over in conditionals.

In dynamic semantics, verbs are taken to introduce events as drefs (Dekker 1993; Bittner 2014; Henderson 2014). Assuming this is on the right track, the dref introduced by $[\![\text{cry}]\!]_d$ is a crying event. However, there is no conclusive evidence on whether $[\![\text{not cry}]\!]$ 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 [kū-méi-kū]^1? Tā lǎopó hǎoxiàng yǒu$_1$.
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. However, the subsequent sentence can only be understood as ‘The event that Libai’s wife cried exists’. If $[\![\text{not cry}]\!]_d$ does not introduce any dref, then its inability to support anaphora is expected. Based on these considerations, there are two possible hypotheses as to the status 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 a verb meaning like $[\![\text{cry}]\!]_d$ into a set $\{[\![\text{cry}]\!]_d, [\textbf{not}\ [\![\text{cry}]\!]_d]\}$. 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 the result of a pragmatic blocking effect. As noticed by a reviewer, conditional constructions are not the only kind of environment where *wh*-questions and polar questions demonstrate a contrast. As mentioned earlier, certain verbs, like *surprise*, are able to embed *wh*-questions but not polar questions (Karttunen 1977), as seen 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 between *wh*-questions and polar questions in terms of the semantic objects that the two types of questions bring into salience, i.e., the semantic objects that they 'highlight' in the terminology of Roelofsen and 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 this kind of reasoning, (74-b) is blocked by (75) because (75) is less complex than (74-b) in terms of syntactic structure.[36]

The blocking analysis can be extended to the unacceptability of (72). The selectional restrictions of question-embedding conditionals and 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 char-

[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.).

actering sets of events. Under this hypothesis, both instances of *kū-méi-kū* only extend an input bottom list by adding a crying event as a dref.

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

In prose: For every accessible world w and event e s.t. e is introduced as a dref by the first 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 second 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).

(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 integrate 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 does so without creating the compositional issues found in alternative approaches.[37]

[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 hùi 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 invite this person.'

The unacceptability of (i) indicates that we would have to impose some sort of novelty condition on 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 this novelty condition to *wh*-expressions. In ordinary *wh*-questions, every occurrence of a *wh*-expression independently denotes a set of dynamic names. There is no anaphoric dependency between these. 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 one 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 instead, according to him. Briefly, Chierchia re-defines syntactic binding as follows: 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).

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 principled way.

6.1 Maximality inference

As observed in previous studies, the consequent of a *wh*-conditional has a maximality inference (Luo and 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 food that you can eat, d is the amount of 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

(ii) [Libai invited [a person]$_1$] [ALWAYS$_1$ [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 of 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 should be pronominal. Unlike pronouns, *wh*-expressions cannot be anaphoric to other expressions.

[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 hùi 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 and 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. By contrast, 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 this maximality inference will have to await future research.

complete propositional answer, and **SA** retrieves from the output of the complete answer a set of entities which completely answer the question in the world under consideration.

(80) $\mathbf{NEC}_{x,w}\ \big[\big[\mathbf{SA}\ [\![\text{who did L invite}]\!]_d\big](x)(w)\big] : \big(\big[\mathbf{SA}\ [\![\text{who did D invite}]\!]_d\big](x)(w)\big)$

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

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 gift 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) $[\![[\text{who}]_{\text{F}}]\!]_d = \{[\![[\text{ANN}]_{\text{F}}]\!]_d, [\![[\text{BOB}]_{\text{F}}]\!]_d, ...\}$

(83) $\{[\![\text{he only sent } [\text{ANN}]_{\text{F}} \text{ a gift}]\!]_d, [\![\text{he only sent } [\text{BOB}]_{\text{F}} \text{ a gift}]\!]_d, ...\}$

I omit the concrete derivation of association with focus, which has been discussed at length in Rooth (1985, 1992), Kratzer (1991), and elsewhere. I refer 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; the *wh*-conditionals are indeed ill-formed.

(84) a. ***Zhǐyǒu** [Lǐbái]$_{\text{F}}$ qǐng-le shéi, [Dùfǔ]$_{\text{F}}$ 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]$_{\text{F}}$ diū-le shěnme, Dùfǔ jiù mǎi shěnme 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.'

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

Although it is still debated what underlies focus intervention effects, many existing semantic analyses of these effects are cast within the framework of Alternative Semantics (Beck 2006; Eckardt 2007; Li and Law 2016; Kotek 2017; Kotek and Erlewine 2018; a.o.). These studies assume that *wh*-expressions denote sets of alternatives (either in the ordinary dimension or in 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.

Let me concretely sketch out how such an analysis could work for focus intervention effects in *wh*-conditionals. Among previous studies, the proposal due to Eckardt (2007) and Li and Law (2016) is least expressive representationally, so it is used for illustration here. Consider (84-a) again. In the antecedent clause, the focus-sensitive particle *zhǐyǒu* 'only' scopes over not only the focused expression but also the *wh*-expression. According to the Roothian multi-dimensional semantics (Rooth 1985, 1992; Kratzer 1991), the focused expression gives rise to a set of alternatives (i.e., $\left[\textbf{Alt}\ [\![\text{Libai}]\!]_d\right] := \{[\![\text{Libai}]\!]_d, [\![\text{Dufu}]\!]_d, ...\}$) in the focus dimension, which is distinct from the ordinary dimension. The ordinary value of the prejacent of *zhǐyǒu* is thus a set of dynamic propositions, 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) $[\![[\text{Libai}]_{\text{F}} \text{ invited who}]\!]_d = \{[\![\text{Libai}]\!]_d \bullet [\![\text{invited}]\!]_d \bullet \beta \mid \beta \in [\![\text{who}]\!]_d\}$

(86) $[\![[\text{Libai}]_{\text{F}} \text{ invited who}]\!]_d^f = \left\{\{\beta' \bullet [\![\text{invited}]\!]_d \bullet \beta \mid \beta \in [\![\text{who}]\!]_d\} \mid \beta' \in \left[\textbf{Alt}\ [\![\text{Libai}]\!]_d\right]\right\}$

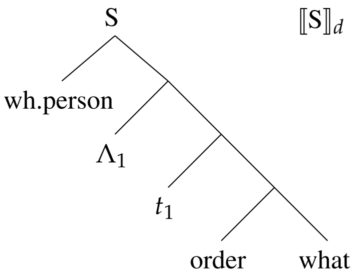
As a focus-sensitive particle, *zhǐyǒu* takes the focus value in (86) as its quantificational domain (Rooth 1985, 1992). However, it requires its domain to be a set containing propositional meanings, instead of a set of sets of propositional meanings. As a consequence, *zhǐyǒu* cannot combine with its 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 yànhùi shàng, **nǎ-gè rén** diǎn-le **shěnme**, **nǎ-gè rén**
this.kind banquet up which-CL person order-CL what which-CL person
jiù chī-le **shěnme**.
then eat-ASP what
'At this type of banquet, what everyone ate are the dishes that they ordered.'

Suppose that today's banquet had only three guests, Ann, Eric, and Carl, and that they each ordered one 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 verify the eating relation in the consequent clause.



$$
\begin{aligned}
[\![\text{S}]\!]_d &= [\![\text{wh.person}]\!]_d \circledast \left\{ \lambda\beta.[\![t_1 \text{ ordered what}]\!]_d^{g^{1\mapsto\beta}} \right\} \\
&= [\![\text{wh.person}]\!]_d \circledast \left\{ \lambda\beta.\, \{ \beta \bullet [\![\text{ordered}]\!]_d \bullet \beta' \mid \beta' \in [\![\text{what}]\!]_d \} \right\} \\
&= \{ \{ \beta \bullet [\![\text{ordered}]\!]_d \bullet \beta' \mid \beta' \in [\![\text{what}]\!]_d \} \mid \beta \in [\![\text{wh.person}]\!]_d \} \\
&= \left\{ \left\{ \begin{array}{l} \beta \bullet [\![\text{ordered}]\!]_d \bullet [\![\textsc{Beans}]\!]_d, \\ \beta \bullet [\![\text{ordered}]\!]_d \bullet [\![\textsc{Salad}]\!]_d, \end{array} \right\} \middle| \; \beta \in \left\{ \begin{array}{l} [\![\textsc{Ann}]\!]_d, \\ [\![\textsc{Eric}]\!]_d, \end{array} \right\} \right\}
\end{aligned}
$$

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

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 key properties of multiple-*wh* questions. In this subsection, I discuss one of these properties, namely the availability of 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 list of person–dish pairs $[x_1, y_1, x_2, y_2 \ldots]$ 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 their denotations 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 then is 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, this intuition has been formalized in Hagstrom (1998), Willis (2008), Fox (2012), Nicolae (2013), Constant (2014), and Kotek (2014) based on static Hamblin se-

[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 pairs of people. This reading can be derived via the basic composition of question meaning, i.e., $[\![\text{who hit who first}]\!]_d = [\![\text{who}]\!]_d \circledast (\{[\![\text{hit}]\!]_d\} \circledast [\![\text{who}]\!]_d) = \{ \beta \bullet [\![\text{hit}]\!]_d \bullet \beta' \mid \beta, \beta' \in [\![\text{who}]\!]_d \}$

mantics. 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]

(90) $$\left\{ \left\{ \begin{array}{l} [\![\text{Ann ordered SALAD}]\!]_d, \\ [\![\text{Ann ordered BEANS}]\!]_d \end{array} \right\}, \left\{ \begin{array}{l} [\![\text{Eric ordered SALAD}]\!]_d, \\ [\![\text{Eric ordered BEANS}]\!]_d \end{array} \right\} \right\}$$
$$= \{ [\![\text{what did Ann order}]\!]_d, [\![\text{what did Eric order}]\!]_d \}$$

I apply an operator $\bigsqcap$, 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) $$\bigsqcap\{Q_1, ..., Q_n\} := \{\phi \mathbin{\triangle} \psi \mathbin{\triangle} ... \mathbin{\triangle} \gamma \mid \phi \in Q_1 \wedge \psi \in Q_2 \wedge ... \wedge \gamma \in Q_n\}$$

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

(92) $$\left\{ \begin{array}{l} [\![\text{Ann ordered SALAD}]\!]_d \mathbin{\triangle} [\![\text{Eric ordered BEANS}]\!]_d, \\ [\![\text{Ann ordered BEANS}]\!]_d \mathbin{\triangle} [\![\text{Eric ordered SALAD}]\!]_d, \\ [\![\text{Ann ordered SALAD}]\!]_d \mathbin{\triangle} [\![\text{Eric ordered SALAD}]\!]_d, \\ [\![\text{Ann ordered BEANS}]\!]_d \mathbin{\triangle} [\![\text{Eric ordered BEANS}]\!]_d \end{array} \right\}$$
$$= \left\{ \lambda w \lambda i \lambda j. \left[\begin{array}{l} \text{order}_w(y_1)(\text{a}) \wedge \text{turn}_w(y_2)(\text{e}) \\ \wedge j = \langle \top_i, \bot_i \cdot \text{a} \cdot y_1 \cdot \text{e} \cdot y_2 \rangle \end{array} \right] \middle| \; y_1, y_2 \in \{\text{s}, \text{b}\} \right\}$$
$$= \left\{ \begin{array}{l} \lambda w \lambda i \lambda j.\text{order}_w(\text{s})(\text{a}) \wedge \text{order}_w(\text{b})(\text{e}) \wedge j = \langle \top_i, \bot_i \cdot \text{a} \cdot \text{s} \cdot \text{e} \cdot \text{b} \rangle, \\ \lambda w \lambda i \lambda j.\text{order}_w(\text{s})(\text{a}) \wedge \text{order}_w(\text{b})(\text{e}) \wedge j = \langle \top_i, \bot_i \cdot \text{a} \cdot \text{b} \cdot \text{e} \cdot \text{s} \rangle, ... \end{array} \right\}$$

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

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

In other words, a sequence of entities that makes (93) dynamically true in a possible world

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41 In addition to the set-of-questions approach followed in 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 with respect to these two approaches. The set-of-questions approach is merely chosen for illustration, in keeping with studies assuming Hamblin semantics, such as Constant (2014) and Kotek (2014).

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 Bumford's 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.

must be one with individuals alternating between people and dishes, as shown below:

w_1 : [ann, salad, eric, beans] w_2 : [ann, beans, eric, salad] ...

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.

(94) Zhè-zhǒng yànhùi shàng, **nǎ-gè rén** diǎn-le **shěnme**, **nǎ-gè rén** jiù chī-le **shěnme**.
this.kind banquet up which-CL person order-CL what which-CL person then eat-ASP what
'At this type of banquet, what everyone ate were the dishes that they ordered.'

(95) $\textbf{NEC}_{\vec{x},w} \begin{cases} \text{Restrictor} & [\textbf{SA}\ [\![\text{wh.person ordered what}]\!]_d]\ (\vec{x})(w) \\ \text{Scope} & [\textbf{SA}\ [\![\text{wh.person ate what}]\!]_d]\ (\vec{x})(w) \end{cases}$

In this representation, **NEC** 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 [**SA** $[\![$wh.person ordered what$]\!]_d$] in w. According to (95), this sequence also saturates [**SA** $[\![$wh.person ate what$]\!]_d$] 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 yànhùi shàng, nǎ-gè rén diǎn-le shěnme, nǎ-gè rén jiù chī-le shěnme.
usually at banquet up which-CL person order-CL what which-CL person then eat-ASP what
'Usually, at a banquet, what everyone ate were the dishes that they ordered.'

(97) $\textbf{usually}_{\vec{x},s} \begin{cases} \text{Restrictor} & [\textbf{SA}\ [\![\text{wh.person ordered what}]\!]_d]\ (\vec{x})(s) \\ \text{Scope} & [\textbf{SA}\ [\![\text{wh.person ate what}]\!]_d]\ (\vec{x})(s) \end{cases}$

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, $\vec{x}$ also completely resolves the issue raised by *Which person ate what* in s.

[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.

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 *wh.one ordered what*	Short answer to *wh.one ate what*
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

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, as done in (97), is the same as quantifying over situations only. 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 one variable over people and another variable over dishes, unlike (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.

But It is too weak: it would predict that (96) is true in the following two scenarios.[45]

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[44] de Swart (1991) argues that quantificational adverbs quantify 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, on 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 situations 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 that it now presupposes that everyone ordered one dish.

(i) Tōngcháng, zài yànhùi 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 were the dishes that they ordered.'

Huang (2018) modifies Cheng and 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 the adverbials/modals included in it.

Situations	Order	Eat
s_1	(Ann, salad)	(Ann, salad)
s_1	(Bob, beans)	(Bob, beans)
s_1	(Cleo, salad)	(Cleo, salad)
s_1	(Tim, salad)	(Tim, salad)
s_1	(Eva, beans)	(Eva, beans)
s_1	(Ivy, beans)	(Ivy, beans)
s_2	(Eva, salad)	(Eva, beans)
s_2	(Bob, beans)	(Bob, salad)
s_3	(Cleo, beans)	(Cleo, salad)
s_3	(Ann, salad)	(Ann, beans)

Situations	Order	Eat
s_1	(Ann, salad)	(Ann, salad)
s_1	(Ann, beans)	
s_1	(Cleo, beans)	(Cleo, beans)
s_1	(Cleo, salad)	
s_2	(Eva, beans)	(Eva, beans)
s_2	(Ivy, beans)	(Ivy, beans)
s_3	(Eva, salad)	(Eva, salad)
s_3	(Eva, beans)	
s_3	(Cleo, beans)	(Cleo, 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 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 verify 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 yànhùi shàng, nǎ-gè rén diǎn-le shěnme, nǎ-gè rén
sometimes at banquet up which-CL person order-CL what which-CL person
jiù chī-le shěnme.
then eat-ASP what
'Sometimes, at a banquet, what everyone ate were 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 which do not necessarily create insurmountable difficulties.

A morphological identity requirement As pointed out in Cheng and Huang (1996), the 'co-referential' *wh*-expressions in a *wh*-conditional must share the same lexical form (see also Bruening and Tran 2006; Chen 2020). For example, in (100), although *nǎ-gè niánqīngrén* and *nǎ-gè qīngnián* both mean 'which youth', they are not interchangable 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 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-gè[1] háizi fàn-le cuò, nǎ-gè[2] jiāzhǎng jiù huì pīpíng $tā_1$.
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) $\textbf{must}_{x,w}\ \big[\,[\textbf{SA}\ [\![\text{wh.kid mistake}]\!]_d]\,(x)(w)\big]:\big(\,[\textbf{SA}\ [\![\text{wh.parent crtz}]\!]_d]\,(f(x))(w)\big)$

The functional dependency may be generalized to all cases of *wh*-conditionals. For an ordinary case, like (100), the function involved 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) $\textbf{NEC}_{x,w}\ \big[\,[\textbf{SA}\ ([\![\text{wh.youth loses}]\!]_d]\,(x)(w)\big]:\big(\,[\textbf{SA}\ ([\![\text{wh.youth pays}]\!]_d]\,(f_{\text{id}}(x))(w)\big)$

Moreover, I conjecture that the application of f_{id} is signaled by 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 implies that Costco is the only place that A can buy wine, hence the name of 'mention-some'.

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

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 mention-some readings is beyond the scope of this paper. I can only sketch a potential approach 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, and maps a mention-some *wh*-question to a set of *multiple* true answers. According to their analysis, we get the following answer sets.

(106) a. For the ordinary *wh*-question *Who lost*, the answer set is:
$\{[\![\text{Bob and Eric lost}]\!]_d\}$, if Bob and Eric both lost

b. For the mention-some question *Where can I buy wine*, the answer set is:
$\left\{ \begin{array}{l} [\![\text{you can buy wine at Costco}]\!]_d, \\ [\![\text{you can buy wine at Safeway}]\!]_d \end{array} \right\}$, if Costco and Safeway 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, $f_{\text{CH}}(\mathbf{Ans}_{\text{Fox-Xiang}}(Q))$ denotes a certain true answer picked out from the set given by $\mathbf{Ans}_{\text{Fox-Xiang}}(Q)$.[46]

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

If the answer set is (106-a), the member picked out by f_{CH} must be the strongest true answer that lists 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 store.

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

(108) $\mathbf{NEC}_{x,w}\,[\,[\mathbf{SA'}\ [\![\text{where can I buy wine}]\!]_d]\ (x)(w)\,]\!:\ (\,[\mathbf{SA'}\ [\![\text{I go where}]\!]_d]\ (x)(w))$

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 $\mathbf{SA}'$ yields one of these stores, either Costco or Safeway. So, in w_1, the speaker can buy wine at either Costco or Safeway and s/he will go to one of these store, not both. Accordingly, the scenario verifying (108) is that the speaker will go to only one 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 reading is also available for *wh*-conditionals with an overt quantificational adverb, as shown in (i). The meaning of this sentence is represented in (ii).

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 have shown that this analysis 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. 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 and Stokhof 1989; Xiang 2020a; a.o.). The dynamic upgrade proposed in this paper reveals that short answers can in fact be derived from propositional answers if these propositions are more highly structured than standardly assumed. 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 have previously been 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.

Acknowledgment This paper is based on Chapter three of my dissertation (Li 2020). I am very grateful to my committee: Anna Szabolcsi, Simon Charlow, Philippe Schlenker, Chris Barker and Adrian Brasoveanu. It also benefited from helpful feedback from many people: Lucas Champollion, Lisa Cheng, Jim Huang, Jess Law, Mingming Liu, Floris Roelofsen, Yimei Xiang, two anonymous reviewers of *Natural Language Semantics*, the editors Angelika Kratzer and Irene Heim, and the copy-editor Christine Bartels. I also thank the audiences at NYU Semantics Group Talk, *MACSIM-8* (NYU), *SALT-29* (UCLA), and *TEAL-12* (University of Macau). I gratefully acknowledge financial support from the National Social Science Fund of China (Grant NO.: 18ZDA291).

(i) Tōngcháng, nǎr néng mǎidào jiǔ, wǒ jiù qù nǎr.
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) $\textbf{usually}_{x,s}\,\big[\,[\textbf{SA}'\,[\![\text{where can I buy wine}]\!]_d]\,(x)(s)\big] : \big(\,[\textbf{SA}'\,[\![\text{I go where}]\!]_d]\,(x)(s)\big)$

In (ii), *tōngcháng* binds both the situation variable s and the entity variable x. Because $\textbf{SA}'$ 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.

A Appendix A: Formal analysis

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

- $a \to b$, 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:

- $\mathbf{t} :: s \to (\sigma \times \sigma) \to (\sigma \times \sigma) \to t$, for dynamic propositions (i.e., a dynamic proposition is an intensional context change potential);
- $\mathbf{e} := (e \to \mathbf{t}) \to \mathbf{t}$, 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
$[\![\text{see}]\!]_d$	$\lambda x \lambda y \lambda w \lambda i \lambda j.\text{see}_w(x)(y) \wedge i = j$	$e \to e \to \mathbf{t}$
$[\![\text{win}]\!]_d$	$\lambda x \lambda w \lambda i \lambda j.\text{win}_w(x) \wedge i = j$	$e \to \mathbf{t}$

Nominals

Expression	Meaning	Type
$[\![\text{Ann}]\!]_d$	$\lambda P \lambda w \lambda i.P(\text{a})(w)(\langle \top_i \cdot \text{a},\ \bot_i \rangle)$	$\mathbf{e}$
$[\![[\text{Ann}]_{\text{F}}]\!]_d$	$\lambda P \lambda w \lambda i.P(\text{a})(w)(\langle \top_i,\ \bot_i \cdot \text{a} \rangle)$	$\mathbf{e}$
$[\![\text{a boy}]\!]_d$	$\lambda P \lambda w \lambda i. \bigcup_{x \in \text{boy}_w} P(x)(w)(\langle \top_i \cdot x,\ \bot_i \rangle)$	$\mathbf{e}$
$[\![[\text{a boy}]_{\text{F}}]\!]_d$	$\lambda P \lambda w \lambda i. \bigcup_{x \in \text{boy}_w} P(x)(w)(\langle \top_i,\ \bot_i \cdot x \rangle)$	$\mathbf{e}$
$[\![\text{she}_0^{\bot}]\!]_d$	$\lambda P \lambda w \lambda i.P((\bot_i)_0)(w)(i)$	$\mathbf{e}$

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 $\bot/\top$ determines which list in an info-state i is processed and the subscript determines which entity is picked out from that list. For instance, given an input info-state i, $[\![\text{she}_0^{\bot}]\!]_d$ 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 $l = [\text{a}_0, \text{b}_1, \text{c}_2]$, l_0 is c.

Sentential operator

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

Scope (Hendriks 1993)

(109) Argument Raising
Let f be any function of type $\vec{a} \to e_n \to \vec{b} \to \text{t}$. $\vec{a}$ 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 $\vec{a} \to \text{e}_n \to \vec{b} \to \text{t}$, where

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

(110) $\left([\![\text{saw}]\!]_d^{\uparrow 1}\right)^{\uparrow 2} = [\![\text{saw}]\!]_d^{\uparrow(1,2)} = \lambda\beta\lambda\beta'.\beta'(\lambda y.\beta(\lambda x.[\![\text{saw}]\!]_d(x)(y)))$ (Surface scope)

(111) $\left([\![\text{saw}]\!]_d^{\uparrow 2}\right)^{\uparrow 1} = [\![\text{saw}]\!]_d^{\uparrow(2,1)} = \lambda\beta\lambda\beta'.\beta(\lambda x.\beta'(\lambda y.[\![\text{saw}]\!]_d(x)(y)))$ (Inverse scope)

Derivation (basic case)

(112)
$$\begin{aligned}[\![\text{Ann saw [a boy]}_{\text{F}}]\!]_d &= [\![\text{saw}]\!]_d^{\uparrow(1,2)}\left([\![\text{[a boy]}_{\text{F}}]\!]_d\right)\left([\![\text{Ann}]\!]_d\right)\\ &= [\![\text{Ann}]\!]_d \left(\lambda y.\ [\![\text{[a boy]}_{\text{F}}]\!]_d \left(\lambda x.[\![\text{saw}]\!]_d(x)(y)\right)\right)\\ &= \lambda w\lambda i\lambda j\exists x.\text{boy}_w(x) \wedge \text{see}_w(x)(\text{a}) \wedge j = \langle \top_i \cdot \text{a},\ \bot_i \cdot x\rangle\end{aligned}$$

A.3 Composition of question meaning

***Wh*-expressions**

Expression	Meaning	Type
$[\![\text{who}]\!]_d^{w_0}$	$\{\lambda P\lambda w\lambda i.P(x)(w)(\langle \top_i, \bot \cdot x\rangle) \mid x \in \text{human}_{w_0}\}$	$\{\mathbf{e}\}$

Alternative-friendly composition

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

Derivation (basic case)[48]

(113) $$\begin{aligned}[\![\text{who saw Ann}]\!]_d &= \big(\eta\big([\![\text{saw}]\!]_d^{\uparrow(1,2)}\big) \circledast \eta\big(\text{Ann}_d\big)\big) \circledast [\![\text{who}]\!]_d \\ &= \Big\{[\![\text{saw}]\!]_d^{\uparrow(1,2)}\big(\text{Ann}_d\big)\Big\} \circledast [\![\text{who}]\!]_d \\ &= \Big\{[\![\text{saw}]\!]_d^{\uparrow(1,2)}\big(\text{Ann}_d\big)(\beta) \mid \beta \in [\![\text{who}]\!]_d\Big\} \\ &= \{\ \lambda w \lambda i \lambda j.\mathsf{see}_w(\mathsf{a})(x) \wedge j = \langle \top_i \cdot \mathsf{a},\ \bot_i \cdot x\rangle \mid x \in \mathsf{human}_{w_0}\}\end{aligned}$$

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

(114) $$\begin{aligned}&[\![\text{who won and what score did she}_0^{\bot}\text{ get}]\!]_d \\ &= [\![\text{who won}]\!]_d \circledast \big(\eta(\triangle) \circledast [\![\text{what score did she}_0^{\bot}\text{ get}]\!]_d\big) \\ &= \{\ \phi \triangle \psi \mid \phi \in [\![\text{who won}]\!]_d \wedge \psi \in [\![\text{what score did she}_0^{\bot}\text{ get}]\!]_d\ \} \\ &= \Big\{\ [\![\text{won}]\!]_d^{\uparrow 1}(\beta) \triangle [\![\text{get}]\!]_d^{\uparrow(1,2)}(\beta')\big([\![\text{she}_0^{\bot}]\!]_d\big) \mid \beta \in [\![\text{who}]\!]_d \wedge \beta' \in [\![\text{what score}]\!]_d\ \Big\} \\ &= \left\{\ \lambda w \lambda i \lambda j.\mathsf{win}_w(x) \wedge \mathsf{get}_w(y)(x) \wedge j = \langle \top_i, \bot_i \cdot x \cdot y\rangle \ \middle|\ \begin{array}{l} x \in \mathsf{hmn}_{w_0} \wedge \\ y \in \mathsf{score}_{w_0}\end{array}\right\}\end{aligned}$$

The retrieving operator SA

(115) $$\begin{aligned}&\mathbf{SA}\ [\![\text{who won}]\!]_d \\ &= \lambda y \lambda w \lambda i \lambda j.\big[\mathbf{Ans}_{w,i}[\![\text{who won}]\!]_d\big](w)(i)(j) \wedge \bot_j - \bot_i = y \\ &= \lambda y \lambda w \lambda i \lambda j \exists x \in \mathsf{hmn}_{w_0}.\mathsf{win}_w(x) \wedge j = \langle \top_i, \bot_i \cdot x\rangle \wedge \bot_j - \bot_i = y\ \wedge \\ &\qquad\qquad \big[\mathbf{Ans}_{w,i}[\![\text{who won}]\!]_d\big] = \big[\lambda w' \lambda i' \lambda j'.\mathsf{win}_{w'}(x) \wedge j' = \langle \top_{i'}, \bot_{i'} \cdot x\rangle\big] \\ &= \lambda y \lambda i \lambda j \exists x \in \mathsf{hmn}_{w_0}.\mathsf{win}_w(x) \wedge j = \langle \top_i, \bot_i \cdot x\rangle \wedge (\bot_i \cdot x) - \bot_i = y\ \wedge \\ &\qquad\qquad \big[\mathbf{Ans}_{w,i}[\![\text{who won}]\!]_d\big] = \big[\lambda w' \lambda i' \lambda j'.\mathsf{win}_{w'}(x) \wedge j' = \langle \top_{i'}, \bot_{i'} \cdot x\rangle\big] \\ &= \lambda y \lambda w \lambda i \lambda j \exists x \in \mathsf{hmn}_{w_0}.\mathsf{win}_w(x) \wedge j = \langle \top_i, \bot_i \cdot x\rangle \wedge x = y\ \wedge \\ &\qquad\qquad \big[\mathbf{Ans}_{w,i}[\![\text{who won}]\!]_d\big] = \big[\lambda w' \lambda i' \lambda j'.\mathsf{win}_{w'}(x) \wedge j' = \langle \top_{i'}, \bot_{i'} \cdot x\rangle\big] \\ &= \lambda y \lambda w \lambda i \lambda j.\mathsf{hmn}_{w_0}(y) \wedge \mathsf{win}_w(y) \wedge j = \langle \top_i, \bot_i \cdot y\rangle\ \wedge \\ &\qquad\qquad \big[\mathbf{Ans}_{w,i}[\![\text{who won}]\!]_d\big] = \big[\lambda w' \lambda i' \lambda j'.\mathsf{win}_{w'}(y) \wedge j' = \langle \top_{i'}, \bot_{i'} \cdot y\rangle\big]\end{aligned}$$

Discussion The essence of the composition proposed here is along the line of Hamblin (1973), Kratzer and Shimoyama (2002), and Shimoyama (2006). The original version of Hamblin semantics composes static meanings, which are trivially transformed into set de-

[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., $x \in \mathsf{human}_{w_0}$ 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 $\{f\{x \mid x \in \text{his paintings}\} \mid f \in \mathsf{CH}\}$. 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 yet has only minimal impact otherwise.

notations. Two alternative sets are composed via the pointwise functional application. In 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 $\circledast$. 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, to combine dynamic meanings. As a result, the two modes of composition are easily integrated with each other.[49]

B Appendix B: Comparison with Dekker's (1993) Existential Disclosure

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

(116) $$\begin{aligned}\mathbf{ED}^{\text{D}}_1\ [\![\text{[a boy]}_1\text{ won}]\!]_d &= \lambda y.[\![\text{[a boy]}_1\text{ won}]\!] \mathbin{\underline{\wedge}} \big(\lambda w \lambda i \lambda j.(\bot_i)_{1-1} = y \wedge j = i\big)\\ &= \lambda y \lambda w \lambda i \lambda j \exists x.\mathsf{boy}_w(x) \wedge \mathsf{win}_w(x) \wedge x = y \wedge j = \langle \top_i, \bot_i \cdot x\rangle\\ &= \lambda y \lambda w \lambda i \lambda j.\mathsf{boy}_w(y) \wedge \mathsf{win}_w(y) \wedge j = \langle \top_i, \bot_i \cdot y\rangle\end{aligned}$$

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

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

(117) $$\begin{aligned}&\mathbf{SA}'[\![...wh_1...wh_n...]\!]_d := \mathbf{ED}^{\text{D}}_{1,...,n}\Big(\mathbf{Ans}(Q)\Big)\\ &= \lambda x_1...\lambda x_n \lambda w \lambda i.\left[\mathbf{Ans}_{w,i}(Q) \mathbin{\underline{\wedge}} \left(\lambda w \lambda i' \lambda j'.\left[\begin{array}{l}(\bot_j)_{n-1}{=}x_1 \wedge ... \wedge\\ (\bot_j)_{n-n}{=}x_n \wedge j' = i'\end{array}\right]\right)\right](w)(i)\\ &= \lambda x_1..\lambda x_n \lambda w \lambda i \lambda j.\big[\mathbf{Ans}_{w,i}(Q)\big](w)(i)(j) \wedge (\bot_j)_{n-1} = x_1 \wedge ... \wedge (\bot_j)_{n-n}{=}x_n\end{aligned}$$

$\mathbf{SA}'$ 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 $\{\, n - n' \mid n' \in \{1, ..., n\}\,\}$ 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).

(118) $$\begin{aligned}&[\![\text{[which person]}_1\text{ ordered what}_2]\!]_d\\ &= \left\{\, \lambda w \lambda i \lambda j.\mathsf{order}_w(y)(x) \wedge j = \langle \top_i,\ \bot_i \cdot x \cdot y\rangle \;\middle|\; \mathsf{hmn}_{w_0}(x) \wedge \mathsf{thg}_{w_0}(y) \,\right\}\end{aligned}$$

[49] Aside from the present 'in-situ' composition, a 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.

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, $\mathbf{SA}'$ can target the drefs x and y by referring to the number of the *wh*-expressions. Specifically, since we have two *wh*-expressions, $(\bot \cdot x \cdot y)_{2-2} = y$ and $(\bot \cdot x \cdot y)_{2-1} = x$.

However, $\mathbf{SA}'$ 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.

(119) $\bigsqcap$ $[\![$[which person]$_1$ ordered what$^2]\!]_d$

$$= \left\{ \lambda w \lambda i \lambda j. \begin{bmatrix} \mathsf{order}_w(y_1)(\mathsf{a}) \wedge \mathsf{turn}_w(y_2)(\mathsf{e}) \\ \wedge\, j = \langle \top_i, \bot_i \cdot \mathsf{a} \cdot y_1 \cdot \mathsf{e} \cdot y_2 \rangle \end{bmatrix} \middle| \; y_1, y_2 \in \{ \mathsf{s}, \mathsf{b} \} \right\}$$

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, 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, $\mathbf{SA}'$ 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 subtraction of lists to generate a list that contains only 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 $\mathbf{ED}_n^{\mathrm{D}}$.

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