Making *wh*-phrases dynamic: A case study of Mandarin *wh*-conditionals

Introduction: This paper is a modest attempt to bring together two lines of research on *wh*-questions (*wh*-Qs) to shed light on Mandarin *wh*-conditionals. On one hand, many studies argue that short answers to *wh*-Qs, such (1), are not reducible to ellipsis and hence must be semantically represented (Groenendijk & Stokhof 1989; Jacobson 2016; Xiang 2016). On the other hand, Hon-coop (1998) and Haida (2007) suggest that *wh*-phrases have dynamic discourse contributions in the sense of introducing discourse referents (drefs), as evidenced by cross-sentential binding (2). In this paper, I propose that the drefs introduced by a *wh*-phrase can be used to model the short answer to the corresponding *wh*-question. I then discuss how this proposal provides a novel analysis for Mandarin *wh*-conditionals (3), which are conditionals with **co-referring** *wh*-phrases showing up in the antecedent clause and the consequent clause (*jiu* is a conditional marker).

(1) A: Who enters?
B: Ahn.

(2) Who$_1$ won the game? What's his$_1$ score?

(3) **Shéi** xīan jìnlái, **shéi** *jìu* xīan chī.
who first enter who then first eat
'Whoever enters first eats first.'

Non-interrogative uses of *wh*-phrases are generally taken to be indefinites. The obligatory co-reference of *who*'s in (3) is puzzling and violates the novelty condition of indefinites (Heim 1982).

Update with centering: Following Bittner (2014) and Murray (2010), I assume that a context c is a set of structured sequences s of drefs (cf. Dekker 1994). Specifically, $s := \langle \top, \bot \rangle$, in which $\top$ is the top sequence representing drefs in the center of attention, while $\bot$ is the bottom sequence representing drefs in the periphery of attention. Sentences denote context change potentials, i.e., functions from context to context. The table below lists some sample lexical items. Proper names can add drefs to $\top$ (when notated with $\uparrow$) or $\bot$. $\top_s$+a is a shorthand for $\langle \top$+a, $\bot\rangle$ and $\bot_s$+b for $\langle \top$, $\bot$+b$\rangle$, where + is sequence extension. Proper names are modeled as generalized quantifiers (GQ). The denotation of *Ahn invites Bill* is composed as in (4).

items	*denotation*
Ahn$^\uparrow$	$\lambda P \lambda c. P(\mathsf{a})(\{\top_s+\mathsf{a} \mid s \in c\})$
Bill	$\lambda P \lambda c. P(\mathsf{b})(\{\bot_s+\mathsf{b} \mid s \in c\})$
invite	$\lambda x \lambda y \lambda c. \{s \in c \mid \mathsf{invite}(y)(x)\}$

(4) $[\![$Ahn invites Bill$]\!]$ =
$\textbf{Ahn}^\uparrow\ \lambda x.(\textbf{Bill}\ \lambda y.\textbf{invite}(y)(x))$ =
$\lambda c.\{\langle \top+\mathsf{a},\ \bot+\mathsf{b}\rangle \mid \langle \top, \bot\rangle \in c,\ \mathsf{invite}(\mathsf{b})(\mathsf{a})\}$

Questions: We follow the spirit of Karttunen's (1977) semantics of *wh*-Qs and propose that *wh*-phrases denote GQs quantifying over proper names, i.e., dynamic GQs, as in (5).

(5) $\textbf{who}^\uparrow := \lambda f. \bigcup \left\{ f(\mathcal{P}) \,\middle|\, \mathcal{P} \in \{\textbf{Ahn}^\uparrow, \textbf{Bill}^\uparrow\} \right\}$

We assume that in *wh*-questions **only** *wh*-phrases introduce drefs to $\top$ (cf. Murray 2010), since they provide the foreground information and establish sets of alternatives that people restrict their attention to (von Stechow & Zimmerman 1984; Krifka 2001; a.o.). The denotation of *who enters* is a set of context change potentials, i.e., possible sentential answers, as in (6) and Figure 1.

(6) $[\![$who enters$]\!] = \textbf{who}^\uparrow\ \lambda \mathcal{P}.\ \textbf{C}(\mathcal{P}\ \lambda x.(\textbf{enter}(x)))$
$= \{[\![$Ahn enters$]\!], [\![$Bill enters$]\!]\}$
$= \left\{ \begin{array}{l} \lambda c.\{\langle \top+\mathsf{a},\ \bot\rangle \mid \langle \top, \bot\rangle \in c,\ \mathsf{enter}(\mathsf{a})\} \\ \lambda c.\{\langle \top+\mathsf{b},\ \bot\rangle \mid \langle \top, \bot\rangle \in c,\ \mathsf{enter}(\mathsf{b})\} \end{array} \right\}$

Short answers: We can extract possible short answers to a *wh*-Q from the set of possible sentential answers to it by using an operator Λ that takes a question Q and returns a dynamic property of sequences i. $\top_{s'} - \top_s$ delivers the sequence that is part of $\top_{s'}$ but not $\top_s$. Any sequence i that has the property consists of drefs introduced by a possible sentential answer p in Q (see Figure 2).

(7) $\Lambda(Q) := \lambda i \lambda c. \bigcup_{p \in Q} \{\ s' \mid s' \in p(c),\ \exists s \in c.\ s \leq s'\ \&\ \top_{s'} - \top_s = i\ \}$

Quantification over short answers: The present proposal accounts for many phenomena that call for the use of short answers to *wh*-Qs—*wh*-conditionals being one of them. Concretely, I propose that the two *wh*-clauses in (3) are questions, (see also Liu 2016), denoting the set Q_1 and Q_2 respectively, and each of them is operated on by Λ. The conditional introduced by *jìu* expresses adverbial quantification: a covert adverbial akin to *always* ($\mathbb{A}$) takes the antecedent clause as restriction and the consequent clause as scope (Kratzer 1981; Cheng & Huang 1996; Chierchia 2000). (3), translated as (8), involves a dynamic universal quantification over sequences. In prose, (8) says: all the sequences that are possible short answers to Q_1 are possible short answers to Q_2.

(8) $$\mathbb{A}_i\Big(\underbrace{\Lambda(Q_1)(i)}_{\text{restriction}}\Big)\Big(\underbrace{\Lambda(Q_2)(i)}_{\text{scope}}\Big) = \lambda c.\left\{ s \in c \;\middle|\; \forall i.\ \Lambda(Q_1)(i)(c) \neq \emptyset \rightarrow \Lambda(Q_2)(i)\Big(\Lambda(Q_1)(i)(c)\Big) \neq \emptyset \right\}$$

As a result, if *Ahn* is the short answer to *who enters first*, then it is also the short answer to *who eats first* (see Figure 3). This is the underlying reason for why the two *who*'s seem to co-refer.

Pair-list readings: In multiple *wh*-conditionals, the *wh*-phrases in the antecedent clause establish a list of pairs, and the *wh*-phrases in the consequent clause give rise to the same list.

(9) **Shéi** ná-le **nǎ** **dào cài**, **shèi** *jìu* yào bǎ **nǎ** **dào cài** chī-wán.
who take-Asp which Cl dish who then must BA which CL dish eat-up
'Everyone who took a dish must finish it.'
(If Ahn took bread and Dufu corn, Ahn must finish beef and Dufu corn; and if Ahn took corn and Dufu bread, Ahn must finish corn and Dufu bread)

Our proposal is compatible with the quantifying-into-question approach in which a multiple *wh*-question can be understood as a conjunction of two questions. For example, the denotation of *who took which dish* is derived in (10). $\sqcap$ is to pointwisely apply dynamic conjunction $\wedge$ to two sets. Finally, different pair lists correspond to different sequences (cf. Bumford 2015).

(10) $$[\![\text{who took which dish}]\!] = [\![\text{Ahn took which dish}]\!] \sqcap [\![\text{Dufu took which dish}]\!] =$$
$$\left\{\begin{array}{l} [\![\text{A took beef}]\!] \wedge [\![\text{D took corn}]\!] \\ [\![\text{A took corn}]\!] \wedge [\![\text{D took beef}]\!] \\ [\![\text{A took beef}]\!] \wedge [\![\text{D took beef}]\!] \\ [\![\text{A took corn}]\!] \wedge [\![\text{D took corn}]\!] \end{array}\right\} = \left\{\begin{array}{l} \lambda c.\{\top_s\text{+b+a+c+d} \mid s \in c,\ \mathsf{take(b)(a)},\ \mathsf{take(c)(d)}\} \\ \lambda c.\{\top_s\text{+c+a+b+d} \mid s \in c,\ \mathsf{take(c)(a)},\ \mathsf{take(b)(d)}\} \\ \lambda c.\{\top_s\text{+b+a+b+d} \mid s \in c,\ \mathsf{take(b)(a)},\ \mathsf{take(b)(d)}\} \\ \lambda c.\{\top_s\text{+c+a+c+d} \mid s \in c,\ \mathsf{take(c)(a)},\ \mathsf{take(c)(d)}\} \end{array}\right\}$$

The *wh*-conditional in (9) expresses: for any sequence i that is a possible short answer to *who took which dish*, i is also a possible short answer to *who must finish which dish*. Given (10), if $i = \mathsf{b+a+c+d}$ is a short answer to the first question, then it is a short answer to the second question, i.e. Ahn must finish beef and Dufu must finish corn.

Coordination: It is well known that the categorial approach (Hausser & Zaefferer 1979) represents the meaning of a *wh*-Q as a set of short answers. However, it cannot represent coordination of *wh*-Qs as sets of short answers (Groenendijk & Stokhof 1989; Xiang 2016). For this reason, it fails to predict the well-formedness of *wh*-conditionals with coordinated *wh*-phrases.

(11) Nǐ chī **shěnme**, hē **shěnme**, wǒ *jìu* yào chī **shěnme**, hē **shěnme**.
you eat what drink what I then must eat what drink what
'No matter what you eat and what you drink, I must eat and drink the same things.'

My proposal can easily capture (11). In the antecedent clause, *you eat what* is conjoined with *you drink what* via $\sqcap$. The short answer is a sequence consisting of a food and a drink. The same mechanism is applied to the consequent clause.

Conclusion: I have proposed a novel way to derive short answers to *wh*-Qs from propositional answers using dynamic semantics. The proposal not only offers an adequate analysis for Mandarin *wh*-conditionals, but can also be extended to English free relatives and quantificational variability effects of *wh*-Qs, which Xiang (2016) has used to motivate the semantic necessity of short answers.

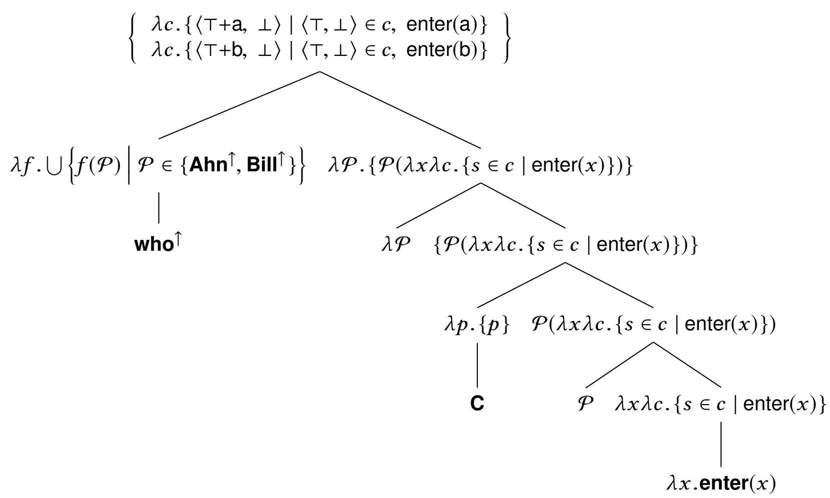

Figure 1: $\textbf{who}^{\uparrow}$ undergoes Quantifier Raising, leaving a 'trace' $\mathcal{P}$ which is itself typed a dynamic GQ and normally takes scope. In this sense, $\textbf{who}^{\uparrow}$ is a higher order dynamic GQ. **C** is the complementizer in the sense of Karttunen (1977), mapping a proposition to a singleton set of the proposition.

$$\{\langle\top,\bot\rangle\} \xRightarrow{\Lambda([\![\text{who enters}]\!])(\mathsf{a})} \left(\begin{array}{l} \xRightarrow{[\![\text{Ahn enters}]\!]} \{\langle\top\text{+a},\bot\rangle\} \xRightarrow{(\top\text{+a})-\top=\text{a}} \{\langle\top\text{+a},\bot\rangle\} \\ \xRightarrow{[\![\text{Bill enters}]\!]} \{\langle\top\text{+b},\bot\rangle\} \xRightarrow{(\top\text{+b})-\top=\text{b}} \emptyset \end{array}\right) \overset{\cup}{\Rightarrow} \{\langle\top\text{+a},\bot\rangle\}$$

(a) Suppose the sequence *i* is a that consist of only *Ahn*.

$$\{\langle\top,\bot\rangle\} \xRightarrow{\Lambda([\![\text{who enters}]\!])(\mathsf{b})} \left(\begin{array}{l} \xRightarrow{[\![\text{Ahn enters}]\!]} \{\langle\top\text{+a},\bot\rangle\} \xRightarrow{(\top\text{+a})-\top=\text{a}} \emptyset \\ \xRightarrow{[\![\text{Bill enters}]\!]} \{\langle\top\text{+b},\bot\rangle\} \xRightarrow{(\top\text{+b})-\top=\text{b}} \{\langle\top\text{+b},\bot\rangle\} \end{array}\right) \overset{\cup}{\Rightarrow} \{\langle\top\text{+b},\bot\rangle\}$$

(b) Suppose the sequence *i* is b that consist of only *Bill*.

Figure 2: Consider (6). The sequences a and b can make $\Lambda([\![\text{who enters}]\!])$ 'true' ($\neq \emptyset$) relative to the input context.

$$\{\langle\top,\bot\rangle\} \xRightarrow{\Lambda([\![\text{who enters first}]\!])(\mathsf{a})} \{\langle\top\text{+a},\bot\rangle\} \xRightarrow{\Lambda([\![\text{who eats first}]\!])(\mathsf{a})} \left(\begin{array}{l} \xRightarrow{[\![\text{Ahn eats first}]\!]} \{\langle\top\text{+a+a},\bot\rangle\} \xRightarrow{(\top\text{+a+a})-(\top\text{+a})=\text{a}} \{\langle\top\text{+a+a},\bot\rangle\} \\ \xRightarrow{[\![\text{Bill eats first}]\!]} \{\langle\top\text{+a+b},\bot\rangle\} \xRightarrow{(\top\text{+a+b})-(\top\text{+a})=\text{b}} \emptyset \end{array}\right) \bigcup$$

Figure 3: The sequence a (only involving *Ahn*) is a possible short answer to *who enters first* and is also a possible short answer to *who eats first*. $\{\langle\top\text{+a+a},\bot\rangle\}$ indicates Ahn enters first and eats first.

Selected references **Bitter**. 2014. *Temporality*. Oxford. **Bumford**. 2015. Incremental quantification and the dynamics of pair-list phenomena. *Semantics & Pragmatics*. **Cheng & Huang**. 1996. Two types of donkey sentences. *Natural Language Semantics*. **Chierchia**. 2000. Chinese conditionals and the theory of conditionals. *Journal of East Asian Linguistics*. **Haida**. 2007. *The indefiniteness and focusing of wh-words*. Phd thesis. **Murray**. 2010. *Evidentiality and the structure of speech acts*. Phd thesis. **Liu**. 2016. *Varieties of alternatives*. Phd thesis. **von Stechow & Zimmermann**. 1984. Term answers and contextual change. *Linguistics*. **Xiang**. 2016. *Interpreting questions with non-exhaustive answers*. Phd thesis.