Varieties of Distributivity:

From Mandarin *Dou* to Plurality, Free Choice and Scalarity

MSc Thesis *(Afstudeerscriptie)*

written by

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Abstract

This thesis examines the semantics of Mandarin particle *dou*, which features various logical uses connecting different subjects in the study of meaning. Three major uses of *dou* are identified—it can function as a quantifier-distributor, a universal free-chocie marker, and a scalar marker introducing *even*-like readings. In order to capture a unifom semantics, we adopt a bottom-up approach that starts with the most common use of *dou*, i.e. as a quantifier-distributor. In particular, we argue that the analysis developed in Lin (1998) that characterizes *dou* as a *generalized distributor* with a *plurality requirement* can be extended to capture its other uses. In deriving its function as a universal free-choice marker, we argue that Mandarin universal free-choice constructions can be treated as a special case of unconditionals, and the free choice effect follows from an implementation of the analysis of unconditionals developed in Rawlins (2008, 2013). In deriving the scalar use of *dou*, we propose the concept of 'scalarization' of the distributivity effect.

Inspired by the ability of *dou* to associate with both plural noun phrases (in the quantifier-distributor use) and *wh*-phrases (in the universal free choice marker use), we further incorporate the analysis into the framework of Dynamic Inquisitive Semantics (Dotlačil and Roelofsen, 2019) that coordinates both plurality and inquisitive informations. The outcome reveals that the *plurality requirement* of *dou* is in fact a certain notion of *inquisitiveness* manifested on different contextual level. This discovery motivates a preliminary post-suppositional analysis of *dou* w.r.t. its quantifier-distributor use, and raises multiple questions left for future research.

Contents

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CHAPTER **1**

Dou: Puzzles and Solutions

1.1 Introduction

Multi-functional particles^{u} in natural language have always captivated linguistic researchers, with their functional diversities sometimes revealing secret paths$^{u'}$ towards language universal, and the process of finding them$_{u'}$ always as fun as solving a burr puzzle. This thesis is centered around one of them$_{u}$, i.e. the Mandarin particle *Dou*. Following Yimei Xiang (2018), we identify three major semantic functions of *dou*—a quantifier-distributor, a universal free choice (∀-FC) marker, and a scalar marker. Among them, the first emerged the earliest (Gu, 2015), and remains the most common. Substantial amount of work has been devoted to decoding its logical function, most of which aims for a uniform analysis that is able to derive its functional and distributional features in a general way. In order to do so, various logical apparatus have been implemented. In this thesis, we strive towards the same goal, but take a slightly different perspective. That is, instead of coming up with a semantic notion that captures everything top-down, we go bottom-up from the most common use of *dou*, namely the quantifier-distributor use, and try to reason hypothetically about the emergence of its various uses. In particular, we propose that Lin (1998)'s characterization of *dou* as a *generalized distributor* (Schwarzschild, 1996) can be adapted to capture its semantic contributions in ∀-FC and scalar constructions. Moreover, the adaptations that are seemingly heterogeneous on a *static* truth-conditional framework can be shown to share a deeper semantic core that will be brought out in the framework of Dynamic Inquisitive Semantics (Dotlačil and Roelofsen, 2019).

The thesis is structured as follows. The rest of Chapter 1 will set up the background via (i) descriptions of the three basic uses of *dou*, i.e. as a quantifier-distributor, a ∀-FC marker and a scalar marker, and (ii) an introduction to representative approaches that account for some or all of them. Chapter 2 defends Lin (1998)'s analysis of *dou* as a *generalized distributor* with a *plurality requirement*, and extends this basic notion to account for the ∀-FC marker use and scalar use. In particular, we propose a novel derivation of the free choice effect via an unconditional analysis (Rawlins, 2008, 2013). Chapter 3 and Chapter 4 are devoted to a translation of the static analysis in Chapter 2 into the framework of Dynamic Inquisitive Semantics (Inq_D) (Dotlačil and Roelofsen, 2019), with the former an introduction to Inq_D, and latter the application. Crucially, the implementation in Chapter 4 demonstrates that the plurality requirement of *dou* manifests itself as different levels of *inquisitiveness*. Chapter 5 concludes with remaining puzzles and future directions.

1.2 Puzzles: the Functional Diversity of *Dou*

1.2.1 Quantifier-Distributor

In its most common use in basic declarative sentences, *dou* is associated with a preceding noun phrase and distributes over its subparts with the remnant predicate. The basic data is given in (1), with the associate of *dou* enclosed in '[·]'. The preceding asterisk '*' and number sign '#' signal *ungrammaticality* and *infelicity*, resp.

(1) a. [Tamen] dou chi -le san-ge niuyouguo.
they **dou** eat -ASP three-CL avocado.
'They *all* ate three avocados.'

b. Tamen ba [san-ge niuyouguo] dou chi -le.
They BA three-CL avocado **dou** eat -ASP.
'They ate *all* of the three avocado.'

c. [Ta] na-ci (*dou) chi -le san-ge niuyouguo.
He that-time (***dou**) eat -ASP three-CL niuyouguo.
'He ate three avocados that time.'

d. *Scenario: On Sunday, Bill, Bob and Barbara rented a boat together and wandered around the canals in Amsterdam.*
[Tamen] (#dou) zu -le yi-sou chuan.
They (#**dou**) rent -ASP one-CL boat.
'They (#all) rented a boat.'

Yimei Xiang (2018) identifies this use of *dou* as a quantifier-distributor, similar to the post-nominal use of *all/both* in English. Meanwhile, the associate of *dou* is always on (or moved to) its left. She further identifies two semantic effects of *dou*—(i) the *distributivity effect* and (ii) the *plurality requirement*[1]. The distributivity effect refers to the cancellation of collective readings. For instance, without the presence of *dou*, the sentence (1a) can mean 'they *each* ate three avocados' or 'they ate three avocados *together*' (ignoring intermediate cumulative readings); but with the presence of *dou*, the latter is blocked. (1b) shows that *dou* can also be associated with pre-verbal objects, and it displays the distributivity effect by asserting that each of the three avocados are eaten (though no collective reading w.r.t. the object is available here). The plurality requirement refers to the fact that the associate of *dou*, overt or covert, must be non-atomic (or divisible, with mass noun phrases). For instance, (1c) shows that when the associate of *dou* is atomic, the sentence is infelicitous. However, by replacing the adverbial '*na-ci*' (one time) with possibly covert '*mei-ci*' (every time), the sentence can be salvaged by an occasion/habitual reading, where *dou* is actually associated with a covert item such as '*mei-ci*' (every time):

(2) Ta [(mei-ci)] dou chi -le san -ge niuyouguo.
He every-time **dou** eat -ASP three -CL avocado.
'He ate three avocados every time.'

[1]Yimei Xiang also identifies a third semantic consequence of *dou*, namely the *maximality requirement*, to which we will come back in §1.3.2, as it motivates the analysis of Ming Xiang (2008) where *dou* is treated as a maximality operator.

Last but not least, (1d) can be seen as a collective result of the two effects: the scenario is set up such that no (true) plural distribution over the associate NP is available. Therefore, in the given context the two semantic contributions cannot both hold, and (1d) is infelicitous.

1.2.2 Universal Free Choice Marker

As has been extensively discussed, *dou* can associate with pre-verbal *wh*-phrases or polarity item '*renhe*' (any) and form ∀-FC constructions. We will refer to this use of *dou* as a ∀-FC marker. The basic data is given in (3):

(3) a. (Wúlùn) [shenme] shuiguo Yuehan *(dou) keyi chi.
(no-matter) what fruit John **dou** may eat.
'John may eat any fruit.'

b. (Wúlùn) [na-ge niuyouguo] Yuehan *(dou) keyi chi.
(no-matter) which-CL avocado John **dou** may eat.
'John may eat any (of the) avocado(s).'

c. [Ren-he shuiguo] Yuehan *(dou) keyi chi.
Any fruit John **dou** may eat.
'John may eat any fruit.'

The universal Free Choice (∀-FC) construction is so called because it expresses 'Freedom of Choice' (Vendler, 1967), and can be paraphrased in the form of a universal quantification[2]. For example, (3b) expresses the 'Freedom of Choice' as the addressee can choose from all the avocados and eat them, and the sentence can be paraphrased as 'for every avocado *x*, you can eat *x*'. A typical Mandarin ∀-FC construction, as we can see in (3), consists of an optional '*wúlùn*' (no-matter), a *wh*-phrase and *dou* (note that the polarity item '*renhe*' (any) can also be decomposed into a '*no matter+wh*' construction). As we will see in §2.2, such constructions share an extremely similar structure with Mandarin unconditionals, with *wúlùn* as the (again, optional) unconditional head, and *dou* obligatory in the consequent. Based on this observation, we will derive in §2.2 the free choice effect of Mandarin ∀-FC constructions from an unconditional analysis (Rawlins, 2013).

1.2.3 Scalar Marker

The last piece of the puzzle regarding the functions of *dou* is its use as a scalar marker, where *dou* is associated with a focused item and produces a scalar reading.

[2]In parallel, there is so called Existential Free-Choice (∃-FC) constructions, which also have the FC component, but lack the universal paraphrase. A classic ∃-FC item is German '*irgendein*', as in the following example:

(i) Du muss irgendein Buch aus der Leseliste lesen.
You must irgend-a book from the reading list
'You must read a book from the reading list.' (Chierchia, 2013, p. 247)

The above sentence has the reading 'you may choose any book from the reading list', but it cannot be paraphrased with universal quantification, such as 'for every book *x* from the reading list, you must read *x*'. Universal and Existential FC constructions also differ in their distributional features and scoping properties (cf. Chierchia, 2013, among many others). The constructions associating with *dou* in (3) all have a universal reading, thus we will refer to them as ∀-FC constructions without further justification.

Yimei Xiang (2018) identified two types of structures where *dou* functions as a scalar marker. The first one, which we will refer to as '(*lian*) Foc *dou*' construction, features *dou* combining with a preceding focused noun phrase that is in turn headed by an optional preposition '*lian*' (along-with):

(4) a. (Lian) $[\text{Yuehan}]_F$ dou chi -le yi-ge niuyouguo.
(LIAN) $[\text{John}]_F$ **dou** eat -ASP one-CL avocado.
'Even John ate an avocado.'

b. Yuehan (lian) $[\text{yi-ge niuyouguo}]_F$ dou mei gei wo sheng.
John (LIAN) $[\text{One-CL Avocado}]_F$ **dou** not give me leave.
'John didn't leave me even one avocado.'

As shown in the examples, the '(*lian*) Foc *dou*' construction typically gives rise to an *even*-like reading, indicating the unexpectedness of the prejacent. (4a), therefore, asserts that John ate an avocado, and it is quite unlikely that he did so. Meanwhile, indefinite phrases of the form 'one-CL-NP' can be licensed in the focal position as a minimizer and implies the truth of all the other alternatives. For instance, (4b) indicates that John didn't leave me (even) one avocado, *let alone* more than one.

Besides preposed focused NPs, *dou* can also be associated with in-situ scalar items and again, implies the unexpectedness (or a relatively high rank on a contextually relevant measure scale) of the prejacent. In this use, '*lian*' is not present in any position.

(5) a. Yuehan dou chi -le $[\text{ba-ge}]_F$ niuyouguo -le.
John **dou** eat -ASP $[\text{eight}]_F$ avocado -ASP.
'John has already eaten eight avocados.' $\rightsquigarrow$ *Eight avocados are a lot.*

b. Tian-tian chi niuyouguo, ta dou chi $[\text{ni}]_F$ -le.
Day-day eat avocado, he **dou** eat $[\text{tired}]_F$ -ASP.
'Eating avocados everyday, he's even tired of it.'
$\rightsquigarrow$ *Being tired of eating avocados suggests a lot of avocado-eating.*

c. (Zhe) dou $[\text{wu dian}]_F$ -le. (Xiang, 2018)
(This) **dou** $[\text{five o'clock}]_F$ -ASP.
'It's five o'clock already!' $\rightsquigarrow$ *five o'clock is quite late.*

To clarify a little bit, (5a) asserts that John has eaten eight avocados, and eight avocados are a lot. (5b) implies that 'being tired of eating avocados', compared to other physical status such as 'enjoy eating avocados', 'enduring eating avocados' etc., occupies a relatively high position on a scale measuring the amount of avocados that are consumed. In (5c), *dou* is associated with the numeral phrase '*wu dian*' (five o'clock), and implies that five o'clock is quite late. Note that in these examples, *dou* is no longer associated with any preverbal noun phrases (in (5c), the expletive '*zhe*' (this) on the subject position can even be covert).

1.3 Solutions: Previous Approaches

In this section, we introduce several influential semantic analyses of *dou*, among which the very first treatment by Lin (1998) is highlighted. As we will see, Lin (1998) initiated the idea that *dou* is a generalized distributor (in the sense of Schwarzschild, 1996) with a plurality requirement. The introductions here will be kept concise with only the key interpretations and brief illustrations on how they can be implemented to capture the uses of *dou* introduced above. Detailed reviews of these approaches, along with their comparisons, will be covered in Chapter 2 where we defend Lin's original proposal.

1.3.1 *Dou* as a Generalized Distributor

Lin (1998) provided one of the very first extensive semantic analyses of *dou*, in which he focused on its quantifier-distributor use. Observing the distributivity effect, he treats *dou* as an overt instantiation of a generalized distributor in the sense of Schwarzschild (1996). The 'generalization' is motivated by the observation that *dou* does not only distribute a plural individual into its atomic subparts, but possibly also to its plural subparts, or even subparts of a mass object:

(6) a. *Scenario: Two couples, Alice and Bill, Amy and Bob each bought a house.*
[Tamen] dou mai -le yi-zhuang fangzi.
They **dou** buy -ASP one-CL house.
'They (all) bought a house.'

b. [Na pen shui] dou lou guang -le.
That basin water **dou** leak empty -ASP.
'The water in the basin has leaked out.'

As shown in (6a), when the plural pronoun '*tamen*' (they) refers to the plural individual 'Alice, Bill, Amy and Bob', the sentence makes perfect sense in the given scenario, and *dou* distributes the plural individual to its plural subparts 'Alice and Bill', 'Amy and Bob'. On the other hand, in sentence (6b), *dou* is associated with a mass object, namely the water in a basin, and *dou* distributes it to its proper subparts and asserts that they all leaked from the basin. Therefore, Lin proposed that *dou* distributes over a contextually determined COVER of its associate, whose definition is given as follow:

(7) Definition of COVER: Schwarzschild (1996)

a. C is a plurality COVER of x, written as $Cov(x, C)$, iff C covers x and no proper subset of C covers x.

b. C covers x iff:

(i) C is a set of subparts of x;

(ii) Every subpart of x belongs to some element of C;

(iii) $\emptyset \notin C$.

With the above characterization of cover, Lin then provided the following semantic interpretation of *dou* (rephrased in a relatively formal manner):

(8) Semantics of dou: Lin (1998)
$[\![dou]\!] = \lambda x_e \lambda P_{\langle e,st\rangle} \lambda w_s. \exists C.Cov(x, C) \wedge \forall y \in C : P(y)(w) = 1$

Therefore, *x dou P* is true iff there is a cover C of x, i.e. $Cov(x, C)$, such that for all $y \in C$, $P(y)$ is true. Here we make a few remarks on the type subscripts. Following the tradition of Intensional Semantics (Ty2,see Gallin, 2016, for details), we assume three basic types in our system, namely the type of entities e, the type of possible worlds s, and the type of truth values t. The set of all types is the closure of the three basic types and their functional abstraction, i.e. if σ, τ are types, then so is $\langle\sigma, \tau\rangle$ (sometimes abbreviated as $(\sigma\tau)$ or $\sigma\tau$). As a result, propositions are of type $\langle st\rangle$, one-place predicates are of type $\langle e, st\rangle$, etc.

Though Lin (1998) did not specifically address the plurality requirement, he made the following observation that leads directly to it:

(9) a. [Wo-men liang-ge ren] (*dou) shi tongxue.
I-PLU two-CL person (***dou**) BE classmates.
'We two are (*both/all) classmates.'

b. [Wo-men san-ge ren] (dou) shi tongxue.
I-PLU three-CL (**dou**) BE classmates.
'We three are (all) classmates.' (from Lin, 1998, p. 235)

In the above examples, since '*shi tongxue*' (be classmates) is a collective predicate that requires at least plural arguments, there is no proper subpart of '*wo-men liang-ge ren*' (we two) that satisfies the predicate, thus (9a) is infelicitous with the presence of *dou*. On the other hand, the plural expression '*wo-men san-ge*' (we three) has proper subparts that can satisfy the predicate—say there are three individuals a, b and i (i represents the speaker), then if $\{a, b, i\}$ are classmates, so are $\{a, b\}$, $\{a, i\}$ and $\{b, i\}$. In this case, *dou* is accepted in sentence (9b). Lin captures this pattern in terms of a *proper subset condition*, spelled out as follows:

(10) *Proper Subset Condition*
Dou only occurs with predicates which have a proper subset entailment on the group argument.

The proper subset condition given by Lin is very close to the plurality requirement we want to capture. However, the condition is only imposed on the predicate associated with *dou*, without saying anything about the noun phrase. But as we observed in (1d), it is really the coordination of the NP and the predicate that matters. That is, the (plural) individual should be covered by at least two of its proper subparts, and they should all satisfy the associated predicate. Therefore, we reformulate the condition as a plurality requirement on the (contextually determined) cover, and revise the above semantics of *dou* as follows:

(11) Semantics of dou (revised): Lin (1998)[3]

$$[\![dou]\!] = \lambda P_{\langle e,st\rangle}\lambda x_e \lambda w_s.\ \underbrace{\exists C.Cov(x,C) \wedge |C| > 1}_{\text{plurality requirement}}\ .\ \underbrace{\forall y \in C : P(y)(w) = 1}_{\text{distributivity effect}}$$

Lin (1998) didn't explicitly address the two other uses of *dou*. In Chapter 2, however, we will show that adaptations of the basic idea presented here are able to capture *dou*'s functions as a∀-FC marker and a scalar marker.

1.3.2 *Dou* as a Maximality Operator

Differing from Lin's original approach, Ming Xiang (2008) proposed that *dou*, instead of a generalized distributor, should be construed as a *maximality operator* (i.e. an iota 'ι' operator). Her account was motivated by the following example:

(12) *Scenario: all the children except for one went to the avocado theme park.*

[3] Lin did not specify the semantic status of the 'proper subset condition'. For the moment we follow Ming Xiang (2008) and Yimei Xiang (2018) and take it as a presupposition.

[Haizi-men] (*dou) qu -le niuyouguo zhuti gongyuan.
Child-PL (***dou**) go -ASP avocado theme park.

'The children (*all) went to the avocado theme park.'

As shown in the above example, *dou* forces the predicate denoted by the remnant VP to be applied to the maximal element in the extension of *dou*'s associate. Based on this observation Ming Xiang (2008) depicted *dou* as a maximality operator with a plurality requirement, defined as follows.

(13) Semantics of *dou*: Xiang (2008)

$$[\![dou]\!] = \lambda x_e.\ \underbrace{\exists C.Cov(x,C) \wedge |C| > 1}_{\text{plurality requirement}} \wedge \underbrace{\exists y \in C[\neg\textsc{atom}(y) \wedge \forall z \in C[z \leq y]]}_{\text{existential presupposition}}.$$
$$\underbrace{\iota y \in C[\neg\textsc{atom}(y) \wedge \forall z \in C[z \leq y]]}_{\text{maximality requirement}}$$

Concretely, Ming Xiang (2008) assumes that in addition to the plurality requirement, *dou* presupposes the existence of a maximal plural element in its associated cover, which it will then operate on (as an iota 'ι' operator) and picks out this maximal plural element.

Ming Xiang then reused this interpretation of *dou* in deriving its scalar use. The idea is that in '(*lian*) Foc *dou*' constructions, *lian* functions as a scalar particle that creates a measure scale of 'unexpectedness' w.r.t. the prejacent, where the denotation of the focused item lies on top above its alternatives. Then the maximality operator *dou* operates on the alternatives and returns the 'maximal' element, yielding the '*even*'-like reading. The detailed analysis will be introduced in §2.3. Meanwhile, this account of *dou* is applied by Giannakidou and Cheng (2006) in the derivation of its ∀-FC marker use, where *dou* functions as a maximality operator that ensures the maximal variation of the intensional environment. The detailed analysis, however, is not immediately relevant for the thesis.

1.3.3 *Dou* as *Even*

Inspired by the scalar use of *dou*, investigations such as Liao (2011) and Liu (2017) have been conducted to explore the theoretical outcomes of equating the semantics of *dou* with English *even*. Liu (2017)'s characterization of *dou* is as follows:

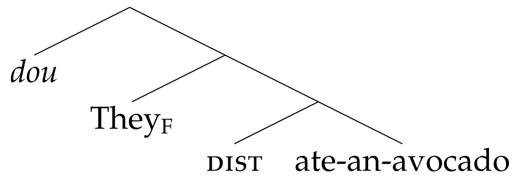
(14) Semantics of *dou* (Liu, 2017)

$$[\![dou]\!] = \begin{cases} \lambda p_{\langle s,t\rangle}\lambda w_s.\, p(w) = 1 & \text{if } \forall q \in [\![p]\!]_{\text{F}}[q \neq p \rightarrow q >_{\text{likely}} p] \\ \text{undefined} & \text{otherwise} \end{cases}$$

Here and henceforth, the double bracket $[\![\cdot]\!]$ subscripted with 'F' is defined as a function that takes a (focused) expression and return the set of its (focus) alternatives (Rooth, 1985, 1992). The entry (14) is then equal to the semantic interpretation of the focus-sensitive particle *even* given by Karttunen and Peters (1979), namely, *dou* is truth-conditionally vacuous, but presupposes that its prejacent is the most unlikely proposition among its alternatives.

Liu characterizes the quantifier-distributor use of *dou* as a 'trivialization' of its *even*-meaning, that is, *dou* plays no part in producing the distributive reading. Rather, it is achieved by a covert distributive operator DIST, which results in a trivial satisfaction of *dou*'s presupposition. We will illustrate with sentence (1a), which receives the following structure given the above assumption:

(15)



Here *they* is subscripted with F as Liu assumed *dou* to be focus-sensitive. Now suppose *they* denotes the sum of individuals 'Alice, Bob and Charlie', written as $a \oplus b \oplus c$. Under the distributive reading, then, the focus set of *they* is claimed to be the 'downward-closure' of its subpart: $[\![\text{they}]\!]_F = \{a, b, c, a \oplus b, a \oplus c, b \oplus c, a \oplus b \oplus c\}$. Meanwhile, we have the simple entailment pattern that if Alice, Bob and Charlie *each* ate an avocado, then it follows that Alice and Bob *each* ate an avocado, and Alice ate an avocado, etc. Moreover, according to the Entailment-Scalarity Principle (Crnič, 2011, 2014), entailment is a stronger form of likelihood—for any two propositions p, q, if p entails q, then p is at least as unlikely as q. Thus the presupposition of *dou* is satisfied under the distributive reading, and its *even*-reading is 'trivialized'.

As a final remark, Liu did not explicitly address the ∀-FC use of *dou*. However, relevant implementations can be found in Liao (2011) and in Appendix II of Yimei Xiang (2018), which we will not discuss further.

1.4 Interim Summary

In this chapter, we introduced the puzzles related to the linguistic functions of *dou*, along with previous approaches providing relevant solutions. The empirical take-aways are the major uses of *dou*—as a quantifier-distributor, as a ∀-FC marker, and as a scalar marker. The theoretical take-aways are the three distinct approaches identifying *dou* as a generalized distributor (Lin, 1998), a maximality operator (Xiang, 2008) and *even* (Liu, 2017). The above list is far from exhaustive. In particular, Xiang (2018) proposes that *dou* is a pre-exhaustification exhaustifier, and this logically rich characterization achieves a uniform analysis for all three uses of *dou*. In Chapter 2, however, we will take a simplistic view and start with Lin (1998)'s original proposal, and argue that the ∀-FC use and the scalar use of *dou* actually follow naturally from the quantifier-distributor use. Detailed reviews and comparisons between the three approaches introduced above will be inserted into the discussion. A comprehensive comparison with Yimei Xiang (2018), however, has to be left for future occasions.

CHAPTER **2**

Dou Stays a 'Generalized Distributor'?

The previous chapter has established three major semantic uses of *dou*, namely (i) as a quantifier-distributor, (ii) as a ∀-FC marker, and (iii) as a scalar marker. We also introduced several extensive semantic analyses of *dou*, all of which aim to unify some or all of these uses. Although the very first of them (Lin, 1997) elegantly captured the quantifier-distributor use by defining *dou* as an overt instantiation of Schwarzschild (1996)'s generalized distributor with a generalized plurality requirement, the others all deviated from this proposal in order to extend the emprical coverage to the uses (ii) and (iii). However, diachronic investigations such as Chen (2018) and Gu (2015) suggest that the quantifier-distributor use of *dou* actually emerged long before the ∀-FC use and the scalar use. Though not decisively, this fact leads to some subsequent questions: Are there any intrinsic connections between distributivity and FC/scalar readings? And if so, in the case of *dou*, how do the latter two stem from the former?

This chapter explores a solution to both questions through an attempt at deriving the uses (ii) and (iii) inheriting Lin's original proposal. The basic idea is, while *dou* stays a generalized distributor with a generalized plurality requirement, it might take arguments of different types, upon which the distributivity effects and plurality requirement might take slightly different forms. The rest of the chapter will start from a more comprehensive recap of Lin (1998) in §2.1, including not only the association of *dou* with definite plurals, but also with other quantificational constructions. §2.2 presents an account for the ∀-FC use inspired by the treatment of unconditionals in Rawlins (2013). §2.3 addresses the scalar-marker use, suggesting a *scalarized* distributivity effect of *dou* when associating with focused scalar items. Before we proceed, it should be noted that the analysis presented in this chapter is 'uniform' only in the sense that *dou* is treated as a generalized distributor with plurality requirement thoughout; as mentioned, the types of arguments that *dou* associates with remain distinct at this stage. A *more* uniform account will be presented in Chapter 4, where the idea from this chapter is incorporated into the framework of Dynamic Inquisitive Semantics with Plurals (Dotlačil and Roelofsen, 2019, layed out in Chapter 3). There we will show that the different types of arguments that *dou* associates with can be retrieved uniformly from the *context* conceptualized in Dynamic Semantics (Groenendijk and Stokhof, 1991; Veltman, 1996; Brasoveanu, 2008, a.o.).

2.1 *Dou* as Quantifier-Distributor

The basic data (1) of *dou* as a quantifier-distributor is repeated here for convenience. As usual, the associate of *dou* is signaled by the '[·]'-enclosure.

(1) a. [Tamen] dou chi -le san-ge niuyouguo.
they **dou** eat -ASP three-CL avocado.
'They *all* ate three avocados.'

b. Tamen ba [san-ge niuyouguo] dou chi -le.
They BA three-CL avocado **dou** eat -ASP.
'They ate *all* of the three avocado.'

c. [Ta] (dou) chi -le san-ge niuyouguo.
He (**dou**) eat -ASP three-CL niuyouguo.
*'He ate three avocados (in one go).'/✓'He ate three avocados (every time he was here).'

d. *Scenario: On Sunday, Bill, Bob and Barbara rented a boat together and wandered around the canals in Amsterdam.*
[Tamen] (#dou) zu -le yi-sou chuan.
They (#**dou**) rent -ASP one-CL boat.
'They (#all) rented a boat.'

Two major semantic consequences of the quantifier-distributor use of *dou* are introduced in Chapter 1: (i) the *distributivity effect* and (ii) the *plurality requirement*. (1a) manifests the distributivity effect by cancelling the collective reading (they ate three avocados *together*) and asserting that each of them ate three. (1b) does so by emphasizing the fact that each of the three avocados is eaten. The plurality requirement is exposed in (1c) where (a) *dou* can be infelicitous when associating with a singular pronoun and (b) it can be salvaged in occasion readings where *dou* actually associates with an implicit plurality of situations. (1d) can be seen as a collective result of the two effects: the scenario is set up such that no (true) plural distribution over the associate NP is available. The example also indicates that the plurality requirement should be relativized to the predicate.

Lin (1998) captures these two semantic consequences by defining *dou* as a generalized distributor in the sense of Schwarzschild (1996), with a plurality requirement. The entry is repeated here:

(11) Semantics of *dou*: Lin (1998)

$$[\![dou]\!] = \lambda P_{\langle e,st\rangle}\lambda x_e \lambda w_s.\ \underbrace{\exists C.Cov(x,C) \wedge |C| > 1}_{\text{plurality requirement}}.\ \underbrace{\forall y \in C : P(y)(w) = 1}_{\text{distributivity effect}}$$

Clearly, as the two semantic effects are encoded directly into the definition, the patterns in (1) are successfully captured. Moreover, we will show that such bipartite definition of *dou* can capture its other uses with slight modifications. In the rest of the section, we will further justify the definition by demonstrating its empirical coverage of *dou* as a quantifier-distributor, through the lens of several opposing arguments.

2.1.1 Is the *plurality requirement* real?

Ming Xiang (2008) first suggested explicitly a presuppositional plurality requirement on *dou*, i.e. an NP should be non-atomic in order to be associated with *dou*[4]. Yimei Xiang (2018) argues that the plurality requirement is 'illusive', as it seems neither sufficient nor necessary in explaining the co-occurrence pattern of *dou* with its associate NP, as shown in the following examples.

(16) a. Ruiqiu ba [na-ge niuyouguo] dou chi -le.
Rachael BA that-CL avocado **dou** eat -ASP
'Rachael ate the whole avocado.'

b. [Tamen -sa/*-lia] dou shi pengyou. (Xiang, 2018)
They -three/-two **dou** be friends.
'They three/*two are all friends.'

In (16a) *dou* associates with '*na-ge niuyouguo*' (that avocado) denoting an atomic individual, hence not necessary; whereas in (16b) the plural expression '*tamen-lia*' (they two) is not compatible with *dou* combined with a collective predicate '*shi pengyou*' (be friends), hence not sufficient. We agree with Xiang's judgement, but we argue that the *plurality requirement* should be interpreted less literally. (11) formalizes the plurality requirement on the associate NP as relative to the predicate P, since its cover C is required to be truly distributed over by P. Such relativization answers to the problem raised by (16b): although '*tamen-lia*' (they two) is a plural expression, it doesn't correspond to a cover with multiple elements that all satisfy the predicate '*shi pengyou*' (be friends), for it requires an argument consisting of at least two atomic individuals. Lin also appeals to this relativized plurality requirement to account for the impossible co-occurrence of *dou* with non-divisive predicates such as 'form this basketball team':

(17) [Tamen] (*dou) zucheng -le zhe-zhi lanqiu dui.
They (***dou**) form -ASP this-CL basketball team.
'They (*all) formed this basketball team.'

To bring out the plurality effect in (16a), let's consider the following contrast:

(18) a. Ruiqiu chi -le na-ge niuyouguo, (dan mei chi wan).
Rachael eat -ASP that-CL avocado, (but no eat finish).
'Rachael ate that avocado (but didn't finish).'

b. Ruiqiu ba [na-ge niuyouguo] dou chi -LE, (*dan mei chi wan).
Rachael BA that-CL avocado **dou** eat -ASP, (*but no eat finish).
'Rachael ate that avocado (*but didn't finish).'

Observe that the exceptive construction 'but didn't finish' is acceptable in (18a) but not in (18b). This contrast indicates that *dou* gives rise to an exhaustivity effect[5]. Yimei Xiang (2018) explains this pattern by resorting to COVER in generating sub-alternatives, which in turn yields the reading that 'for any proper sub-part y of the avocado x ($y \prec_{\text{PART}} x$), it is not the case that Rachael only ate y'. The plurality requirement then echoes with the

[4]This is actually a conclusion from arguing against Lin's generalized distributor account: a generalized distributor cannot rule out the collective reading as in (1d). However, as the reader has probably noticed, Lin's plurality condition is already able to avoid this problem, and it actually stands against all the subsequent counter arguments.

[5]This also motivates the *maximality*-operator account in Ming Xiang (2008). See §2.1.3 for more discussions.

non-vacuity presupposition: A non-empty set of sub-alternatives implies the existence of a proper sub-part of x, and according to the definition of a COVER, it must contain at least one other element that help cover the complementary part of x, thus the plurality. Unsurprisingly, such plurality can be implemented to explain the co-occurrence of *dou* with mass expressions as well.

(19) [Beizi li de shui] (dou) lou chulai -le.
Cup in NOM water (**dou**) leak out -ASP.
'The water in the cup (all) leaked out.'

Therefore, we conclude that a generalized plurality requirement that is relativized to the predicate does exist as a semantic contribution of *dou*.

2.1.2 Is the *distributivity effect* real?

The main arguments against *dou* being a distributor are as follows. First, we have established that *dou* triggers a distributivity effect that is rather flexible: contrary to *strict* distributors like *every/each* that distribute down to the atomic components of their argument, *dou* presents a more abstract distributive pattern. This is why Schwarzschild's generalized distributor is needed. However, as pointed out in Cheng (2009) and Ming Xiang (2008) (among others), defining *dou* as a generalized operator cannot rule out the case where the associated COVER is a singleton set. This tension is resolved directly here with the generalized plurality requirement spelled out. The second, and more interesting opposing opinion concerns the co-occurrence pattern of *dou* with other distributive expressions in Mandarin. Here we consider the following three, along with a rough English translation: *mei*-CL (every), *gezi* (each) and *quan* (all).

(20) a. [Mei-ge tongxue] (dou) dai -le liang-ge landiao de niuyouguo.
Every-CL student (**dou**) bring -ASP two-CL rotten NOM avocado
'Every student brought two rotten avocados.'

b. [Niuyouguo] quan (dou) lan -le.
Avocado all (**dou**) go-off -ASP
'All the avocados went off.'

c. [Bier, Baobo he Babala] gezi (dou) dai -le yi-ge landiao de
Bill, Bob and Barbara each (**dou**) bring -ASP one-CL rotten NOM
niuyouguo.
avocado.
'Bill, Bob and Barbara each brought a rotten avocado.'

The three distributive expressions can all co-occur with *dou*. On the other hand, their English counterparts tend to refuse co-occurring with each other:

(21) a. Every avocado (*each/??all) went off.

b. The avocados all (*each) went off.

c. Bill Bob and Barbara each (*all) brought a rotten avocado.

This does look like a convincing argument against *dou* as a distributor. A common solution, consequently, is to simply strip the distributivity effect from *dou* and give it to a covert distribution operator DIST (cf. Liao, 2011; Liu, 2017), whose position can also be overtly taken by the above mentioned distributive expressions. However, the following example from Szabolcsi (2010) and Champollion (2015) might be suggesting a different way out:

(22) Every boy ate two sausages each.

Here a distributive expression *each* can grammatically occur in the scope of the universal quantifier *every*. We will follow Champollion (2015) and name such pattern 'distributive concord'. Other than English, as pointed out by Champollion, languages like Korean, German, and Japanese are also reported to admit analogous sentences. We list these examples here, with an addition of the Mandarin counterpart:

(23) sonyen (-tul) -mata sosici twu- kay- **ssik-** ul mek- ess- ta. (*Korean*)
boy PL every sausage two CL **each** ACC eat PAST DECL
'Every boy ate two sausages each.'

(24) Jeder Junge hat **jeweils** zwer Wüstchen gegessen. (*German*)
Every boy has **each** two sausage eaten.
'Every boy ate two sausages each.'

(25) Subete-no danshi-ga sosegi-o fu-tatsu-**zutsu** tabeta. (*Japanese*)
Every-GEN boy-NOM sausage-ACC two-CL-**each** ate.
'Every boy ate two sausages each.'

(26) Mei-ge nanhai gezi chi -le liang-gen xiangchang.
Every-CL boy **each** eat -ASP two-CL sausage
'Every boy ate two sausages each.'

Champollion (2015) treated the distributive elements such as **each** in (22) as dependent numerals, analogous to dependent indefinites (Farkas, 1997; Henderson, 2014). He claims that they do not introduce distributivity themselves, but instead are licensed by it. Adopting the framework of Dynamic Plural Predicate Logic with post-suppositions (Brasoveanu, 2012; Henderson, 2014), he analyzed the adnominal *each* as a '*post-suppositional plug*' that checks if every boy has eaten distinct two sausages. The formal analysis will be in place after the dynamic system is layed out in Chapter 3, here we will try to give an informal explanation, adopting Champollion's 'river metaphor'.

Imagine information flows like a river. The river flows downward: from c-commanding positions to the c-commanded ones, from restrictors to quantifiers, from antecedents to consequents, and overall from anaphoras to dependent pronouns. As a framework for representing information flows, Dynamic Semantics (Kamp, 1981; Heim, 1982, a.o.) translates natural language sentences into Discourse Structures consisting of discourse referents (dref) and conditions. We can construe the introduction of a dref with index *i* as boat(s) with loaded cargo launched with a flag '*i*', and the conditions as stationary sentinels carrying special orders through whom every boat needs to pass. Post-suppositions are traveling sentinels with sealed instructions which will be conducted when the boat is about to pass the stationary sentinels. With this simple setup, the sentence (22) flows like this. ⟦every boy$_i$⟧ launches every boy on a different boat with a flag '*i*'. The distributive force associated with *every* splits each boat into a distinct river branch. Then on each branch, ⟦two sausages$_j$⟧ then launches a boat loaded with two sausages under the '*j*' flag. They start sailing together. Right before the boats are about to pass the sentinels ⟦*ate*⟧ assigned to each branch, the traveling sentinel ⟦*each*⟧ opens up the sealed instruction and reads: 'check that the boats sailing under the *j* flag don't carry the same two sausages'. It then does so. If the boats at all branches pass the test, they can go on and face the stationary sentinels. And if every boy on the *i* boats ate the two sausages on the companion *j* boat, they can pass the sentinel and reach the harbor.

Crucially, this analysis retains the adnominal *each* as a distributive expression, even though it is in the scope of a universal quantifier *every* that introduces an additional distributivity effect. Moreover, the post-suppositional condition introduced by *each* seems to inherit the distributivity effect of *each*: the traveling sentinel *distributively* checks each river branch, and makes sure each boy has different two sausages to eat. Therefore, we claim that the contrast between (20) and (21) is not fatal to the account of *dou* as a distributor.

If it is on the right track to analyze the sentences in (20) as examples of 'distributive concord', then it would be interesting to find out the postsuppositional condition contributed by *dou*. It is tempting to analyze *dou* here analogous to *each*, as (20a) does force the interpretation where every student brought different two rotten avocado. However, (20a) suggests the opposite as the sentence is still true even if all the avocados are rotten to the same degree. Meanwhile, the optional appearences of *dou* in (20) seems to indicate a vacuous reading. We don't have anything conclusive to say about this, but we suggest a post-suppositional *dou* might still have (subtle) semantic contributions, as shown by the contrast below.

(27) a. [Tamen] dou du -le zhanzheng yu heping.
They **dou** read -ASP war and peace.
'They all read *war and peace*.'

b. [Tamen] gezi ?(dou) du -le zhanzheng yu heping.
They each ?(**dou**) read-ASP war and peace.

(28) Shu jia shang you ji-ben shu. [Tamen] gezi/?dou na le yi-ben.
Book shelf on have several-CL books. They **each**/?**dou** pick -ASP one-CL.
'There are some books on the shelf. They each/all picked one.'

When one specific book (*war and peace*) is fixed in the verbal predicate *read war and peace*, possible variations seem to be very limited. In this case, (27b) indicates that the distributive concord of *gezi* and *dou* seems to be preferred over *gezi* used alone. On the other hand, when different (yet specific) books are given in the context, as in (28), the use of *gezi* is preferred over *dou*. This might suggest that *gezi* expresses certain at-issue variations of its adjacent predicate w.r.t. each distributed individuals, whereas *dou* expresses at-issue indifference. A comprehensive investigation, however, has to be left to future work.

2.1.3 Is the *maximality requirement* real?

Here we address the last semantic consequence of *dou*, namely the maximality requirement. It refers to a 'strict exhaustivity effect', as shown above in (18) and here in (29):

(29) *Scenario: all the children except for one went to the avocado theme park.*

[Haizi-men] (*dou) qu -le niuyouguo zhuti gongyuan.
Child-PL (***dou**) go -ASP avocado theme park.

'The children (*all) went to the avocado theme park.'

Here the use of *dou* is unacceptable as the context forces a strictly non-exhaustive reading of the sentence, contradicting the maximality requirement. Motivated by such examples, Ming Xiang (2008) defined *dou* as a maximality (iota 'ι') operator with a plurality requirement, as shown in 13. In the following, we argue against the primary status of the maximality requirement in two steps. First we show that the strict exhaustivity effect can be derived from the distributivity requirement. Second, we show that the maximality requirement is not in place to explain the co-occurrences of *dou* with generalized quantifiers such as *dabufen* (most), *many* (half), etc.

2.1.3.1 Maximality as Homogeneity Removal

For step one, we resort to the trivalent approach to homogeneity (Križ, 2015). It is observed that sentences with definite plurals feature the property of *homogeneity* (Schwarzschild, 1993; Löbner, 2000; Gajewski, 2005; Magri, 2013, a.o.):

(30) a. The children went to the avocado theme park. $\rightsquigarrow$ **All** of the children went to the avocado theme park.
   b. The children didn't go to the avocado theme park. $\rightsquigarrow$ **All** of the children didn't go to the avocado theme park.

In particular, the homogeneity effect introduced by definite plurals gives rise to an 'extension gap' where intermediate cases lie (e.g. for the above example (30), i.e. cases where *some but not all* of the children went to the theme park). Križ (2015) elegantly conceptualized this pattern in terms of trivalent logic, where besides TRUE (1) and FALSE (0), there is a third truth value UNDEFINED (#). Moreover, negation switches TRUE and FALSE, but leaves UNDEFINED untouched. Thus a diagnosis for sentence (30) is as follows:

(30a) 'The children went to the avocado theme park.'

TRUE iff all of the children went to the theme park.

FALSE iff none of the children went to the theme park.

UNDEFINED otherwise (i.e. some but not all of the children went to the avocado theme park).

The acceptance of (29) can then be classified into the wider-range phenomenon of *non-maximality*:

(31) *Scenario: After Sue's defense, all the professors smiled, except for the perpetually dour Prof. Smith. Sue's friend Alice says to her...*

Alice: The professors smiled. (Križ, 2015)

Even with the exception Prof. Smith, the sentence (31) is still acceptable as long as the exception is *irrelevant* for current conversational purposes (Lasersohn, 1999): say it is common knowledge that Prof. Smith never smiles and it is not a big deal if he doesn't. On the other hand, if Sue really cares about Prof. Smith's opinion and is stressed about his cold reaction, she might come up with the following negative response:

(32) Sue: No, Smith didn't.

Following this observation, Križ (2015) captures *non-maximality* as a *quality implicature*, with a weakened MAXIM of quality:

(33) (WEAK) MAXIM OF QUALITY
A speaker may say only sentences which, as far as she knows, are *true enough*.

Where the notion of *true enough* (or *sufficient truth*) is captured as an at-issue indifference from literally true sentences (for details, see Križ, 2015, Ch. 3).

With this extremely simplified set up, the question of interest here is then how quantifiers like *all* and *dou remove* homogeneity and eliminate non-maximality, as in (18) and (29). Again, Križ (2015) provided a intuitive solution, based on the empirical investigation reported in Križ and Chemla (2015). The informal proposal is as follows:

(34) Given the scope predicate P, a quantifier Q is

TRUE iff it is true no matter how the undefined cases of the scope predicate are (uniformly) resolved;

FALSE iff it is false no matter how the undefined cases of the scope predicate are (uniformly) resolved;

UNDEFINED otherwise.

Let's first illustrate with the predicate '*ate the avocados*' in the scope of a universal quantifier *every student*:

(35) Every student ate the avocados.

Consider a domain of students consisting of three individuals $\{a, b, c\}$, and a situation where each student is assigned three avocados. The predicate '*ate the avocados*' (written as E) of type $\langle e, st\rangle$ can be represented as a function from individuals to truth values. Now suppose student a and b ate all of the three avocados, but student c only ate two of them. Then the extension of the predicate E is as follows:

$$E = \begin{bmatrix} a \mapsto 1 \\ b \mapsto 1 \\ c \mapsto \# \end{bmatrix}$$

Now, following (34), we tentatively resolve the UNDEFINED truth value assigned to c as 0 and 1:

$$E^0 = \begin{bmatrix} a \mapsto 1 \\ b \mapsto 1 \\ c \mapsto 0 \end{bmatrix} \quad E^1 = \begin{bmatrix} a \mapsto 1 \\ b \mapsto 1 \\ c \mapsto 1 \end{bmatrix}$$

Finally, when combined with the universal quantifier '*every student*', E^0 yields FALSE, whereas E^1 yields TRUE. Therefore we conclude that the truth value of sentence (35) is UNDEFINED. Meanwhile, it should be easy to realize that if student b didn't eat any of the avocados (i.e. $E(b) = 0$), *Ceteris paribus*, then no matter how the truth value of c is resolved, E will be FALSE combined with '*every student*', hence (35) will be FALSE.

We can now return to the original example (29). *Dou* forces the strict exhaustivity/maximality as follows. First, '*went to the avocado theme park*' is *distributive* in the sense that it maps each individual to a truth value that is not '#' (everyone either went to the park or not, no intermediate stage). Then, the distributor '*dou*' elicits a one-by-one evaluation of each individual child, and outputs '0' whenever it catches one that didn't go to the park. As we can see, then, the *distributivity effect* of *dou* is exactly the reason the exhaustive reading is derived.

2.1.3.2 Co-occurrence of *dou* with *most*

We argue that the co-occurrence of *dou* with generalized quantifiers (GQ) such as '*dabufen*' (most) and '*henduo*' (many) goes against the ι-operator account of *dou*, as follows:

(36) a. [dabufen xuesheng] (dou) chi -guo niuyouguo.
Most students (**dou**) eat -EXP avocado.
'Most students have eaten avocados.'

b. [henduo xuesheng] (dou) canjia -le bisai.
many student (**dou**) participate -ASP game.
'Many students participated in the game.'

Note that *dou* is optional in both sentences[6]. Such co-occurrence is compatible with the generalized-distributor account for *dou*. Assume the following semantics for *dabufen*, equivalent to the generalized quantifier *most*:

(37) Semantics of *dabufen*:
$[\![dabufen/(\text{most})]\!] = \lambda P_{\langle e,st\rangle}\lambda Q_{\langle e,st\rangle}\lambda w.\, |P^{w}_{\text{ATOM}} \cap Q^{w}_{\text{ATOM}}| > |P^{w}_{\text{ATOM}} \backslash Q^{w}_{\text{ATOM}}|$

Here '$\cap$','$\backslash$' are binary connectives between the set of extensions of P and Q at world w (written as P^w, Q^w) and '$|\cdot|$' is the cardinality function. Moreover, since we want the elements in the extension sets to be possibly plural, the subscript ATOM is used to restrict an extension set to its atomic component so that number information can be incorporated in a correct way. For any predicate P of type $\langle e, st\rangle$ and world w, P^{w}_{ATOM} is defined as follows:

(38) $P^{w}_{\text{ATOM}} := \{x \mid x \text{ is atomic and there is } y \text{ such that } P(y)(w) = 1 \text{ and } x \text{ is a subpart of } y\}$

Importantly, P^{w}_{ATOM} contains both the atomic elements in the extension of P at w, and the atomic components of plural elements. As a result, if P is distributive, then P^{w}_{ATOM} is equivalent to the set of atomic elements in P^w, thus (correctly) leaves out the plural ones in the comparison of cardinalities as in (37); if P is collective, the rendering also yields a correct reading of sentences like '*most people gathered*'—the number of *atomic* components of the population that gathered is more than half. Finally, the semantics of (36a) can be computed as follows:

(39) a. $[\![xuesheng/(\text{student})]\!] = \lambda x_e \lambda w_s.\, {}^*\textbf{student}(x)(w) = 1$,
where * is the pluralization operator per Link (1983).
We denote its extension at world w as S^w;

b. $[\![chi\ \text{-}guo\ niuyouguo/\text{have eaten avocados}]\!] = \lambda x_e \lambda w_s.\, {}^*\textbf{Eat-Avo}(x)(w) = 1$;

c. Applying the semantics of *dou* in (11), we get:
$[\![dou \text{ have eaten avocados}]\!] = \lambda x_e \lambda w_s. \exists C.Cov(x, C) \wedge |C| > 1.$
$\forall y \in C : {}^*\textbf{Eat-Avo}(y)(w) = 1$
We denote its extension at world w as $DouE^w$;

[6]Previous literatures such as Lin (1998) and Cheng (2009) have reported that the presence of *dou* is obligatory in the scope of '*most*'. I don't totally agree, especially in generic sentences as follows:

(1) dabufen dongbei hu shennghuo zai yuan dong diqu, yi lu, yezhu deng dongwu wei shi.
Most northeast tiger inhabit at far east area, as deer, boar etc animal for food.
'Most Siberian tigers live in the Far East, hunting animals like deers and wild boars for food.'

d. Finally, apply (a) and (c) to (37): $[\![(36a)]\!] = \lambda w_s. |S^w_{\text{ATOM}} \cap DouE^w_{\text{atom}}| > |S^w_{\text{ATOM}} \backslash DouE^w_{\text{ATOM}}|$

The final result (39d) captures the correct interpretation for (36a), i.e. more than half of the students have eaten avocados. In particular, we assume the plurality requirement of *dou* is locally accommodated (Heim, 1983) to ensure the set of students who have eaten avocados is plural. On the other hand, the maximality-operator account of *dou* doesn't seem to work as smoothly. According to (13), *dou* takes a plural entity x and returns the unique maximal element of its (contextually-determined) cover C, while presupposing the plurality of C. We can see that there is a type mismatch: *dou* defined in (13) is of type $\langle e, e\rangle$, and if '*dabufen*' (most) stays a generalized quantifier (type $\langle\langle e, st\rangle, \langle\langle e, st\rangle, t\rangle\rangle$) and combines with its restrictor first, it is impossible to accommodate both *dou* and its adjacent predicate. Assuming *dou* can also take properties of type $\langle e, st\rangle$ as arguments (as Xiang did in capturing its ∀-FC use, discussed in the next section) will not help here, for similar reasons. Set aside the type issue, even if we construe the function of '*dabufen*' (most) simply as carving out a more-than-half portion of its associate, what is the maximizing *dou* here? Clearly it cannot be maximizing '*most* NP', as there is no unique maximal way of carving out such portion. Cheng (2009) proposed that on a par with other definite determiners in Greek and Basque, *dou* provides domain restriction that is required for strong quantifiers such as '*Mei*' (every), '*suoyou*' (all) and '*dabufen*' (most). She then predicts the obligatoriness of *dou* in the scope of these quantifiers (which we don't totally agree, as shown above in 36 and footnote 6). Meanwhile, as Cheng (2009) reported, *dou* can also license a conjoined NP:

(40) [dabufen xuesheng he mei-ge laoshi] dou dao zao -le.
Most student and every-CL teacher **dou** arrive early -ASP.
'Every teacher and most students arrived early.' (Cheng, 2009)

Cheng therefore claims that (contrary to the definite particles in Basque and Greek), *dou* is a DP-external determiner. However, it seems that *dou* can move further away from the NP:

(41) [dabufen xuesheng] zai lai zhe zhiqian dou mei chi -guo niuyouguo.
Most student at come here before **dou** not eat -EXP avocados.
'Most students haven't eaten avocados before they came here.'

Here in (41) *dou* is not even adjoined to the NP '*most student*' - a temporal adverbial '*before coming here*' comes between them, while '*dou*' still seems to distribute/maximize over the NP. It cannot be associating with the temporal adverbial, since the following reading doesn't seem to be available: 'During all the period of the time before they came here, the students didn't/haven't eat(en) avocados.'

Based on the above discussions, therefore, we have enough reason to believe that *dou* is a quantifier-distributor that is adjoined to the VP, rather than a maximality operator that adjoined to the NP.

2.2 *Dou* as ∀-FC Marker

The second major semantic use of *dou* is to associate with preceding *wh*-expressions (optionally headed by '*wúlùn*', no-matter) or the polarity item '*renhe*' ('no-matter-what', any) and yield universal Free-Choice readings. The basic data (3) is repeated here for convenience:

(3) a. (Wúlùn) [shenme] shuiguo Yuehan *(dou) keyi chi.
(no-matter) what fruit John **dou** may eat.
'John may eat any fruit.'

b. (wúlùn) [na-ge niuyouguo] Yuehan *(dou) keyi chi.
(no-matter) which-CL avocado John **dou** may eat.
'John may eat any (of the) avocado(s).'

c. [Ren-he shuiguo] Yuehan *(dou) keyi chi.
NoMatter-what fruit John **dou** may eat.
'John may eat any fruit.'

Current approaches that account for this use of *dou* are inspired either from mechanisms that have been developed to account for FC items (Yimei Xiang, 2018), or from cross-linguistic FC constructions that show structural similarities (Giannakidou and Cheng, 2006). In this section, we will propose a novel perspective to tackle the problem, i.e. *unconditionals*, which is motivated by the resemblance between the surface structures of ∀-FC constructions and unconditionals in Mandarin Chinese. We propose an account for the Free Choice inference analogous to Rawlins (2013)'s analysis of unconditionals.

2.2.1 *Dou* in Unconditionals

As shown in (3a) and (3b), the *wh*-associates of *dou* in ∀-FC constructions can be headed by '*wúlùn*' (no-matter). On the other hand, '*wúlùn*' is a typical unconditional head in Mandarin Chinese, with *dou* (or other particles with universal quantificational force, e.g. '*zong*' (always)) obligatorily present in the consequent[7], as illustrated by the following examples.

(42) a. (Wúlùn) paidui shang you mei-you niuyouguo, Yuehan *(dou) keyi qu.
No-matter party on have not-have avocado, John *(**dou**) may go.
'Whether there are avocados on the party or not, John should go.'

b. (Wúlùn) paidui shi zai bier jia haishi baobo jia, Yuehan *(dou) keyi qu.
No-matter party BE at Bill house or Bob house, John *(**dou**) may go.
'Whether the party is at Bill's house or Bob's house, John may go.'

c. (Wúlùn) paidui zai shui jia, Yuehan *(dou) keyi qu.
No-matter party at who house, John *(**dou**) may go.
'No matter whose house the party will be, John may go.'

Just like in English, the unconditional antecedent headed by *wúlùn* can be a polar-or-not question, an alternative question, or a *wh*-question. And like in ∀-FC constructions, *wúlùn* can be optional (though often preferred to be overt). Unconditionals are closely related to conditionals in the sense that the former can be paraphrased as a conjunction of the latter. For instance, the unconditional (42a) can be rendered as "I will go to the party if there will be avocados, and I'll go if there isn't." Rawlins (2008, 2013) translated this intuition clearly into the Hamblin-Style Alternative Semantics with point-wise compositions (Hamblin, 1973; Kratzer and Shimoyama, 2002). Specifically, Rawlins follows the Hamblin Semantics of questions, where an interrogative sentence denotes

[7] Lin (1997) claims that *wúlùn* always precedes the '*wh...dou*' construction, overtly or covertly. We take a neutral stand on whether this is the case.

the set of propositions that answer it; then each of these propositions is treated as providing a conditional antecedent that gives rise to a modal-base restriction over which the consequent will be evaluated (following the tradition of Lewis and Keenan (1975), Kratzer (1981) and Heim (1982)); finally, the set of conditional propositions generated by the previous point-wise composition is conjoined by a universal [∀]-operator, and the unconditional is true if this conjunction is. As introduced above, Rawlins assumes the following Logical Form (**LF**) for unconditionals:

(43) **LF**: [[∀] [[Q] *wh*/∨]...], where
  a. '*wh*/∨' signals an alternative-generating antecedent, typically through *wh*-questions, alternative questions or polar-or-not questions;
  b. [Q] is a question operator calling for a question as argument and letting through the alternatives generated by the antecedent;
  c. [∀] is a universal operator that intersects the point-wise *if*-composition of (the set of) antecedents and consequent.

Furthermore, Rawlins argues that the question operator [Q] introduces an *exhaustivity* presupposition and a *mutual-exclusivity* presupposition w.r.t. its adjacent. The *exhaustivity* presupposition requires the issue denoted by the antecedent to be contextually non-informative; and the *mutual-exclusivity* presupposition requires the alternatives generated by the antecedent are incompatible with each other. These are arguably the case for alternative and polar-or-not questions (for *wh*-questions, see further discussions in §2.2.1.1). Formally, assume the speaker's utterance is based on a context *c* modeled as a set of possible worlds representing public mutual commitments (Stalnaker, 1978), the question operator [*Q*] works as follows (we use superscript *h* to signal that the denotation is formed in Hamblin Semantics, and the subscript *c* signals the relativization to context *c*):

(44) $[\![[Q]\alpha]\!]^h_c = [\![\alpha]\!]^h_c$, defined only if
  a. $\forall w \in c : \exists p \in [\![\alpha]\!]^h \text{ s.t. } p(w) = 1$ (*Exhaustivity*)
  b. $\forall p, p' \in [\![\alpha]\!]^h_c : (p \neq p') \rightarrow \neg\exists w \in c.\, p(w) = p'(w) = 1$ (*Mutual-Exclusivity*)

Finally, let's illustrate the derivation of unconditional semantics with the sentence (42b).

(45) Wúlùn paidui shi zai bier jia haishi baobo jia, Yuehan *(dou) keyi
  No-matter party BE at Bill house or Bob house, John *(**dou**) may
  qu.
  go.
  'Whether the party is at Bill's house or Bob's house, John may go.'
  a. $[\![[Q]\ \textbf{Whether...Bill's...or...Bob's}]\!]^h_c = \left\{ \begin{array}{l} \lambda w.\text{ Party at Bill's at } w \\ \lambda w.\text{ Party at Bob's at } w \end{array} \right\}$, if
    a. $\forall w \in c$: Party at Bill's at w ∨ Party at Bob's at w
    b. $\forall w \in c$: ¬(Party at Bill's at w ∧ Party at Bob's at w)
  b. $[\![\textbf{John may go}]\!]^h_c = \lambda w.\, \exists w' \in MB_d(w)$[John goes at w'], where $MB_d(w)$ represents the deontic modal base at w i.e. the set of worlds that are deontically accessible from w.

c. Point-wise *if*-Composition:
⟦[Q] **Whether...Bill's...or...Bob's(John may go)**⟧ =
$$\left\{\begin{array}{l}\lambda w^{@}.\,\exists w' \in \mathrm{MB}_d(w^{@}) \cap (\lambda w.\,\text{Party at Bill's at } w).\,[\text{John goes at } w'] \\ \lambda w^{@}.\,\exists w' \in \mathrm{MB}_d(w^{@}) \cap (\lambda w.\,\text{Party at Bob's at } w).\,[\text{John goes at } w']\end{array}\right\} =: [\![Q]\!]$$

d. Applying Universal Operator [∀]: $[\![(42b)]\!] = \lambda w.\,\forall p_{st} \in [\![Q]\!] : p(w) = 1$

The final reading of (42b), then, is given in (45d), with the presuppositions specified in (45a). To accommodate with the framework Dynamic Inquisitive Semantics (Inq_D) introduced in Chapter 3 and 4, we will provide a translation of Rawlins's analysis from Hamblin Semantics to Inquisitive Semantics, together with some empirical motivation for such transition. The semantics of *dou* in unconditional consequent (written as dou_Q) will then naturally follow.

2.2.1.1 Inquisitive Semantics Inq_B

Inquisitive Semantics (Inq_B) (Ciardelli et al., 2018) starts out with the promise to unify the semantic notions of declarative and interrogative propositions, as they both play a fundamental role in information exchange. At the core of the integration lies the basic notion of *inquisitive propositions*, defined as follows. Note that the definition is given on a semantic level, formalized with possible world semantics.

Definition 2.1. (Inquisitive Propositions)

- An information state is a set of possible worlds.
- An inquisitive proposition is a non-empty, **downward closed** set of information states.

Noticeably, the notion of an *information state* equates with the classic notion of a (non-inquisitive) proposition. In inquisitive semantics, then, the propositional semantics is *lifted* from a set of possible worlds to a set of sets of possible worlds, just as in Hamblin Semantics. However, Inquisitive Semantics differs from Hamblin Semantics in that except for the lifting, it also requires the set of information states to be *downward-closed* in order to form an inquisitive proposition. This requirement can be motivated from the following aspects. First, in formalizing the semantics of a question, we often refer to the set of propositions that *resolve* the question. However, if a proposition P resolves a question φ, then any stronger proposition P', i.e. P' denotes a subset of the set of worlds denoted by P, also resolves φ. Therefore if we want to include in the semantics of a question all the propositions that resolve the question, the downward closure seems to be a natural choice. Second, for declarative propositions, the downward closure helps lift their type up to the same level, so that they can be operated uniformly with questions. In the following, we will refer to declarative sentences as *non-inquisitive*, and questions as *inquisitive*. They will both be generally referred to as *issues*. As a result, an inquisitive proposition can be uniformly thought of as raising an issue. The inquisitiveness of an issue is defined through the following notion of Alternatives:

Definition 2.2. (Alternatives)

An information state α is an alternative of an issue φ if:

a. $\alpha \in \varphi$;

b. $\neg\exists\alpha'$ s.t. $\alpha' \in \varphi$ and $\alpha \subsetneq \alpha'$

The set of alternatives of an issue φ is written as $\mathsf{alt}(\varphi)$.

That is, an alternative is a maximal element in the corresponding inquisitive proposition. Such elements can be called 'alternatives' as the members in Hamblin sets because they represent similar notions: the *weakest* propositions that resolve a question. Consequently, we call an issue P *inquisitive* if it contains more than one alternative, and *non-inquisitive* if it only has one. While the set of alternatives can be seen as contain the inquisitive information of an issue, we can also retrieve the informative content using the function info:

Definition 2.3. (Informative Content)
The informative content of an issue φ: $\mathsf{info}(\varphi) = \{w \in s \,|\, \text{for some } s \in \varphi\}$

Given the basic propositional language $\mathcal{L}$ of $\mathsf{Inq_B}$, we can define the semantics of logical connectives as follows:

Definition 2.4. (The basic propositional language $\mathcal{L}$)

$\varphi ::= p \,|\, \neg\varphi \,|\, \varphi \wedge \varphi \,|\, \varphi \vee \varphi$, where p is an atomic proposition from an denumerably infinite set P

Unlike the notations above where all the propositions are equivalent to their semantic content by default, here we will use $[\![\cdot]\!]$ to highlight the semantic interpretation:

Definition 2.5. (Semantics of propositional $\mathsf{Inq_B}$)

Given a model $\mathcal{M} = \langle W, V\rangle$ where W is a set of possible worlds and $V : W \times P \to \{0, 1\}$ a valuation function:

- $[\![p]\!] = \{s \subseteq W \,|\, \forall w \in s : V(w, p) = 1\}$
- $[\![\neg\varphi]\!] = \{s \subseteq W \,|\, \forall t \in [\![\varphi]\!] : t \cap s = \emptyset\}$
- $[\![\varphi \wedge \psi]\!] = [\![\varphi]\!] \cap [\![\psi]\!]$
- $[\![\varphi \vee \psi]\!] = [\![\varphi]\!] \cup [\![\psi]\!]$

In particular, the negation of an issue is always non-inquitive, whereas the disjunction of two non-inquisitive proposition might turn out to be inquisitive (this is how we capture alternative questions).

There are two *projection operators* ! and ? that are commonly used.

Definition 2.6. (Projection Operators)

- The *issue-cancelling* operator !: $!\varphi := \wp(\mathsf{info}(\varphi))$
- The *info-cancelling* operator ?: $?\varphi := \varphi \cup \varphi^*$, where φ^* denotes the complement set of φ, i.e. the semantics of $\neg\varphi$

The operators are so called because ! turns an issue φ into a non-inquisitive proposition with the unique alternative $\mathsf{info}(\varphi)$, and ? turns an issue φ into a non-informative proposition $\varphi \vee \neg\varphi$. In particular, the latter provides a simple logical counterpart of polar questions.

Finally we give the first-order extension of $\mathsf{Inq_B}$with a (rigid) interpretation model.

Definition 2.7. (The Language of First-Order $\mathsf{Inq_B}$)

$\varphi ::= R(t_1, ..., t_n) \,|\, \neg\varphi \,|\, \varphi \wedge \varphi \,|\, \varphi \vee \varphi \,|\, \forall x.\varphi(x) \,|\, \exists x.\varphi(x)$, where

- R is an n-ary relational symbol from a set $\mathcal{R}$;
- $t_1, ..., t_n$ are *terms* from the set of constants $\mathcal{C}$, or a functional expression $f(t')$ where f is a function from a set $\mathcal{F}$, and t' another term;
- x is a variable.

Definition 2.8. (Rigid Interpretation Model for First-Order $\mathsf{Inq_B}$)

A rigid interpretation model for first-order $\mathsf{Inq_B}$is a triple $\langle W, D, I\rangle$ where:

- W is a set of possible worlds;
- D is a non-empty set of individuals;
- I is a interpretation function s.t. for every world $w \in W$:
  - for every constant c, $I(c) \in D$;
  - for every n-ary function symbol $f \in \mathcal{F}$, $I(w)(f) : D^n \to D$, and for all $w, v \in W$, $I(w)(f) = I(v)(f)$;
  - for every n-ary relational symbol $R \in \mathcal{R}$, $I(w)(R) \subseteq D^n$

Definition 2.9. (Semantics of First-Order $\mathsf{Inq_B}$)
Given a rigid interpretation model $\mathcal{M} = \langle W, D, I\rangle$

- $[\![R(t_1, ..., t_n)]\!] := \{s \subseteq W \,|\, \forall w \in s : \langle I(w)(t_1), ..., I(w)(t_n)\rangle \in I(w)(R)\}$;
- $[\![\neg\varphi]\!] := [\![\varphi]\!]*$;
- $[\![\varphi \wedge \psi]\!] := [\![\varphi]\!] \cap [\![\psi]\!]$;
- $[\![\varphi \vee \psi]\!] := [\![\varphi]\!] \cup [\![\psi]\!]$;
- $[\![\forall x.\varphi(x)]\!] := \bigcap_{d\in D}[\![\varphi(d)]\!]$;
- $[\![\exists x.\varphi(x)]\!] := \bigcup_{d\in D}[\![\varphi(d)]\!]$.

Note that just like disjunctions, existential quantification in first-order $\mathsf{Inq_B}$ can also result in inquisitiveness. In particular, it can be used as a logical counterpart of *wh*-questions.

We will end this introduction with some remarks on the type system. Since the propositional semantics is characterized as a set of sets of possible worlds, in the class TY2 system, they are of type $\langle st, t\rangle$. We will abbreviate this type as T, and all the other types are defined accordingly, e.g. one-place predicate $\langle e, T\rangle$, etc. For more details on the English fragments, we refer to Ciardelli et al. (2017).

2.2.1.2 Lifting Conditionals

Now let's translate Rawlins (2013)'s analysis for unconditionals into $\mathsf{Inq_B}$. The reason for adopting the framework of inquisitive semantics is mainly technical: as it provides an elegant characterization of question semantics, and we will adopt its dynamic extension $\mathsf{Inq_D}$in Chapter 3 and 4 to capture a unified picture for the semantics of *dou*. However, there is also an empirical advantage in using inquisitive semantics. Consider the following example with a *wh*-antecedent:

(46) No matter who comes, John will invite him/her for dinner.[8]

Here the most salient conditional paraphrase seems to be: 'if Alice comes, John will invite her for dinner' and 'if Bob comes, John will invite him for dinner', etc. However, such paraphrase does not force the antecedents to be mutually exclusive, as the case for alternative questions. That is, it can also be inferred from (46) that 'if Alice and Bob come, John will invite them for dinner', hence the coming of Alice is compatible with the coming of John. This non-exhaustive reading of the *wh*-antecedent can be easily captured by inquisitive semantics, as it allows overlapping alternatives[9]. Therefore, here we assume that the *mutual-exclusivity* presupposition is a requirement introduced by alternative questions only (though it is enforced by the semantics of polar-or-not question as well), and for *wh*-antecedents, they only require contextual inquisitiveness and exhaustivity, and multual-exclusivity may come in as contextual restrictions.

The semantics of unconditionals can be modeled in inquisitive semantics by the notion of *lifted conditionals* (Ciardelli, 2016). Classical accounts of conditionals usually define them as an operation $\Rightarrow$ between propositions (information states). Here we give an extremely simplistic notion of the operation $\Rightarrow$ featuring only material implications, leaving out various fine-grained structural pieces (e.g. relative similarity per Lewis (2013), premise sets per Kratzer (1981), etc.):

Definition 2.10. Given a set of possible worlds W and any $P, Q \subseteq W$,

$$P \Rightarrow Q := \{w \in W \mid w \in W \backslash P \text{ or } w \in Q\}$$

Ciardelli (2016) takes '$\Rightarrow$' as an ingredient for the lifting, as it provides a basic-level operation over information states. The lifting up to the inquisitive level is then given as follows:

Definition 2.11. Given two inquisitive propositions φ and ψ,

$$\varphi > \psi := \{s \mid \forall \alpha \in \mathsf{alt}(\varphi) : \exists \beta \in \mathsf{alt}(\psi). s \subseteq \alpha \Rightarrow \beta\}$$

Ciardelli (2016) then managed to capture various (un)conditional structures uniformly with the notion $>$, including plain conditionals, conditional questions and unconditionals. In case of unconditionals, the logical skeleton $\varphi > \psi$ is fleshed out with an inquisitive antecedent φ and a non-inquisitive consequent ψ. Thus we get the following rendering of **Definition** 2.11 that is more comparable to Rawlins's characterization:

[8] Note that here the cross-sentential binding 'John' - 'him' calls for a dynamic interpretation. We can easily capture this after introducing dynamic inquisitive semantics.

[9] Note that the partition framework (Groenendijk and Stokhof, 1984) that treats question semantics as the set of *exhaustive* answers will also derive the correct interpretation here—no matter who *all* come, John will invite them for dinner—so mutual-exclusivity doesn't *need* to be dropped here. However, as exemplified by (46), doing so would lead to a more flexible treatment with more intuitive touch.

(47) Given an inquisitive antecedent φ and a non-inquisitive consequent ψ,

$$\varphi > \psi = \{s \mid \forall\alpha \in \mathsf{alt}(\varphi) : s \subseteq \alpha \Rightarrow \textsc{info}(\psi)\}$$
$$= \{s \mid s \subseteq \cap_{\alpha\in\mathsf{alt}(\varphi)}[\alpha \Rightarrow \mathsf{info}(\psi)]\}$$

Note that the outcome in (47) predicts correctly the non-inquisitiveness of the unconditional proposition: the resulting truth set is the downward closure of the conjunction of $\alpha \Rightarrow \mathsf{info}(\psi)$ w.r.t. the set of alternatives α of φ. The former is an information state, and conjunctions of information states cannot create inquisitiveness.

2.2.1.3 *Dou*$_{\mathrm{Q}}$

With inquisitive semantics and its interpretation for unconditionals, we can finally move to the Mandarin data and disect the semantic contribution of *dou*. To avoid confusion, we will mark *dou* in unconditionals or ∀-FC constructions as *dou*$_{\mathrm{Q}}$. At this point, the basic semantic features, namely the plurality requirement and the distributivity effect, seem to have already found their correspondence - *dou*$_{\mathrm{Q}}$ associates with the unconditional antecedent, requires it to be (contextually) inquisitive (the *plurality* of the set of alternatives), and distributes over the alternatives in order to produce the universal reading w.r.t. their implications towards the consequent. Before moving on to the formal definition, let's start with a few remarks. First, the inquisitiveness of the antecedent seems to be a general requirement for unconditionals - after all, in languages like English, the inquisitiveness presupposition still exists, but there is no (obligatory) particle in the consequent to enforce the effect. Therefore the plurality requirement of *dou* might only be in agreement with the same requirement given by the unconditional antecedent. Second, we need justifications for associating *dou*$_{\mathrm{Q}}$ with the antecedent. For all the cases in (42), *dou* still occupies the position below the subjects (of the consequents), so the possibility of *dou* associating with them is not ruled out at first glance. However, notice that in these cases, the subject NP denotes the atomic individual John, and its association with *dou* will not be able to avoid violations of the plurality requirement. Meanwhile, even if the subject position is occupied by a plural expression, we can still argue that they are not the associates of *dou*$_{\mathrm{Q}}$. Consider the following example:

(48) Wúlùn shui lai, Yuehan he Mali *(dou) hui qing ta chi wanfan.
No-matter who come, John and Mary **dou** will invite him/her eat dinner.
'No matter who comes, John and Mary will invite him/her for dinner.'

If *dou* takes the plural subject 'John and Mary' as argument, then we should get the reading 'no matter who comes, John and Mary will invite him/her for dinner, separately'. Though such reading is available given certain contexts, the collective reading 'no matter who comes, John and Mary will invite him/her for dinner together' is also acceptable (if not preferred). Further, if *dou*$_{\mathrm{Q}}$ really associates with the subject, we lose the explanation of its obligatory presence in unconditionals (as shown in 42)—Since the collective reading and distributive reading of (48) are both available, *dou*, as a distributor over the subject, is not really needed. Meanwhile, the obligatoriness can be easily accounted for if *dou*$_{\mathrm{Q}}$ is connected to the antecedent - the distributivity effect is needed to provide the universal force that is necessary for an unconditional interpretation.[10]

Thus, assuming (with justifications) that *dou*$_{\mathrm{Q}}$ takes the unconditional antecedent as argument, we give the following semantics (49) for *dou*$_{\mathrm{Q}}$ in inquisitive semantics. Again,

[10] A syntax-semantics study of *dou*, in particular it's relation/difference with the universal operator [∀], is left for future occasions.

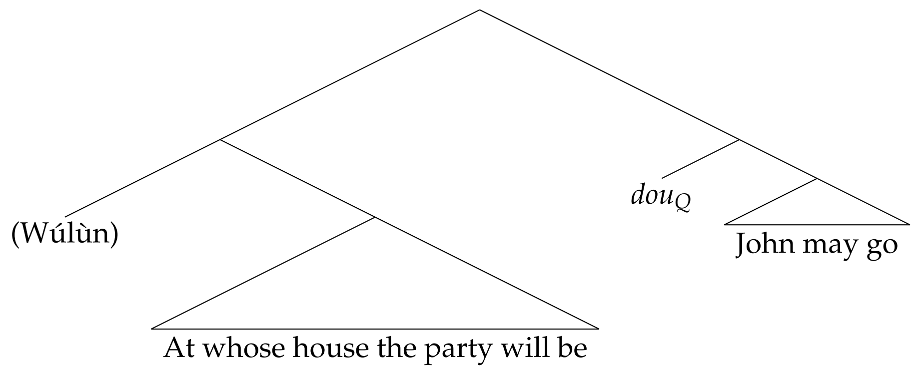
the subscript c denotes the context set, modeled as a set of possible worlds.

(49) $[\![dou_Q]\!]_c = \lambda P_T \lambda Q_T \lambda s_{st}.\ \underbrace{|\mathsf{alt}(Q_c)| > 1}_{\text{plurality}}\ .\ \underbrace{\forall \alpha \in \mathsf{alt}(Q_c) : s \subseteq [\alpha \Rightarrow \mathsf{info}(P_c)]}_{\text{distributivity effect}}$

Here is some clarifications for the notations P_c, Q_c: whereas P, Q denotes general inquisitive propositions, the subscripted versions P_c, Q_c denotes their *relativized* semantic value w.r.t. the context set c, which are defined as $P_c := \{s \cap c \,|\, s \in P\}$ (and same for Q_c). Finally, let's illustrate the semantic composition of Mandarin unconditonals with (42c) as a working example.

(50) (Wúlùn) paidui zai shui jia, Yuehan *(dou) keyi qu.
No-matter party at who house, John *(**dou**) may go.
'No matter at whose house the party will be, John may go.'

a. Assuming the following surface structure:



b. $[\![(\textit{wúlùn})$ **at whose house...** $]\!] = \lambda s_{st}.[\exists x.\ \text{Party at } x\text{'s house}](s) = 1$, defined if
$=: Q$

(i) $\forall w \in c : \exists \alpha \in \mathsf{alt}(Q_c).w \in \alpha$ (*exhaustivity*[11])

(ii) $|\mathsf{alt}(Q_c)| > 1$ (*inquisitiveness*)

c. $[\![$**John may go**$]\!] = \lambda s_{st}.\ \forall w \in s : \exists w' \in \text{MB}_d(w).\ \text{John go at } w' =: P$

d. $[\![(42c)]\!]_c = [\![dou_Q]\!]_c(Q)(P)$
$= \lambda s_{st}.\ |\mathsf{alt}(Q_c)| > 1.\ \forall \alpha \in \mathsf{alt}(Q_c) : s \subseteq [\alpha \Rightarrow \{w \in c \,|\, \exists w' \in \text{MB}_d(w).\ \text{John go at } w'\}]$

Thus we obtain the reading of (42c) in (50d), along with the presuppositions given in (50b). As a final remark, note that (50d) differs in form with (45d) in that we treated conditional antecedents as modal-base restrictions (following Rawlins) in (45d), but not here. We can imagine a simple rephrase of (45d) into a modal-restrictional notion, as follows:

(50d′) $[\![(42c)]\!] = \lambda_{st}.\ |\mathsf{alt}(Q_c)| > 1.\ \forall \alpha \in \mathsf{alt}(Q_c) : s \subseteq \{w \in c \,|\, \exists w' \in \text{MB}_d(w) \cap \alpha.\ \text{John go at } w'\}$

(50d′) is stronger than (50d) in the sense that not only does the former entails the latter, it has the additional requirement that for any information state s that satisfies the resolution condition in (50d′), any world $w \in s$ corresponds to a deontic modal base $\text{MB}_d(w)$ that intersects with all the alternatives of Q_c, i.e. $\text{MB}_d(w) \cap \alpha_c \neq \emptyset$, for all $\alpha \in \mathsf{info}(Q_c)$. Then imagine an example of Q_c with two alternatives, e.g. the party is either at Alice's house or Bill's house. Then the above requirement gives us the reading that 'the party *may* be

[11] Here we follow Rawlins and name this feature *exhaustivity*, but note that it is equivalent to *non-informativeness* in Inquisitive Semantics.

at Alice's house' and 'the party *may* be at Bill's house' (with a deontic 'may'), namely permissions that the party can be at their houses. But this reading does not usually follow from (42c). Note that the problem also appears in (45d) as the truth is evaluated over a single world. We see this as another advantage of adopting the framework of inquisitive semantics: by lifting the notion of meaning, it manages to seperate the deontic permission from the antecedent (and operates solely on the consequent), thus avoid the additional reading as described.

2.2.2 From Unconditionals to Free Choice

So far the section has been focusing on the semantics of (Mandarin) unconditionals and the role that *dou* plays in it. Now let's get back to the puzzle that led us here: *dou* associating with *wh*-NPs headed by optional *wúlùn* gives rise to a ∀-FC reading. We propose an analysis that follows directly from the semantics of unconditionals established just now.

2.2.2.1 Proposal

A main claim of Rawlins (2013) is that unconditionals convey **orthogonality** (Lewis, 1988) between the antecedent issue and the consequent. Informally, the **orthogonality** between two issues I_1 and I_2 means they *cut across* each other: resolving either one wouldn't do any good in resolving the other. Rawlins provided a formal yet visualized characterization of orthogonality using Partition Semantics (Groenendijk and Stokhof, 1984). Partition Semantics represents the meaning of an issue with an equivalence relation over the world domain W, thus creates a 'partition'. Each equivalence class corresponds to a *complete/exhaustive* answer to the question. The formal definition of orthogonality is given as follows:

Definition 2.12. (Orthogonality: in Partition Semantics)

Given a world domain W, two issues $I_1, I_2 \subseteq \wp(W)$ are *orthogonal* relative to a context c iff for all $p_1 \in I_1$, $p_2 \in I_2$, there is a world $w \in c$ s.t. $w \in p_1$ and $w \in p_2$.

Let's illustrate with a natural language example. Let I_1 be the issue 'where will the party be?', and I_2 'can/may John go to the party?'. Consider a scenario where there will be a party, and it can only be at Alice's (a), Bill's (b) or Charlie's (c). Then I_1 creates the partition over C as in Fig. (2.1a). Now if I_2 (with two equivalence class j ('John may go') and $\neg j$ ('John may not go')) is inserted into the picture as in Fig. (2.1b), then we can conclude the orthogonality of I_1 and I_2. It follows directly from Definition 2.12 - for any $p \in I_1$ ($p \in \{a, b, c\}$), p intersects with both j and $\neg j$, vice versa. On the other hand, if the context is given that 'John may not go if the party is at Alice's (enclosed by the dashed area in Fig. (2.1c)), then I_1 and I_2 are no longer orthogonal. In the new context, the alternative in I_1 establishing that the party is at Alice's also entails the information that John may not come; in other words, it fails to intersect with the j-worlds. Finally let's consider the conditional sentence 'No matter whose house the party is at, John may go' (in the original context). An implementation of the unconditional analysis introduced above would give us the semantic value enclosed in the rectangle as in Fig. (2.1d). If we take a minimal dynamic perspective and take the function of propositions as updating the context (eliminating the contradictory worlds), then the result of the update via unconditional sentence seems to be the same as just asserting 'John may go'. What is the semantic contribution of the additional unconditionality, then? As should be quite obvious at this point, Rawlins claims that by imposing an issue in the antecedent, unconditionals also contribute with the orthogonality of the antecedent and consequent.

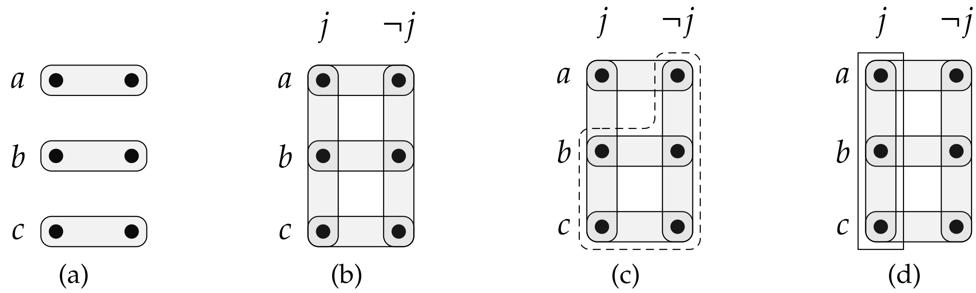


Figure 2.1: Orthogonality in Partition Semantics

The orthogonality story is indeed very conceivable, and it provides an intuitive conceptualization of a semantic flavor that is conveyed by a wide range of natural language expressions - for example, as pointed out by Rawlins himself, "the notion of orthogonality provides a useful and powerful unifying meta-characterization of many 'free choice' effects". This section is definitely an attempt to realize such vision. Before delving into the discussion of ∀-FC constructions, however, we will make a subtle change on Rawlins's characterization of unconditionals. Rawlins claimed that the orthogonality conveyed by an unconditional holds between the antecedent and the *consequent*. But just like in (donkey) conditionals, unconditional antecedent and consequent might have an anaphoric/binding relation, which in turn will sabotage the orthogonality. Consider the following example:

(51) No matter who_1 comes, John will invite him/her_1 for dinner.

The shared index '1' indicates a binding relation between *who* and the pronoun *him/her*. The orthogonality doesn't hold between the antecedent and the consequent, since the answer to the antecedent question non-trivially contributes to the outcome of the consequent. If it is the case that Alice comes, then John will invite Alice for dinner, and if it's Bill, John will invite Bill, etc. Conversely, if John will invite Alice for dinner, then it rules out the case where Alice is not coming, etc. On the other hand, the orthogonality flavor clearly survives in spite of the binding - the *identity* of the person who actually comes wouldn't affect the fact that John will invite him/her for dinner. In order to resolve the tension, we hereby claim that the orthogonality in unconditionals is not between the antecedent and the *consequent*, but between the antecedent and the propositional content of the unconditional as a whole. Then for the case of (51), an unconditional analysis would give us a non-inquisitive proposition φ where for any world $w \in \mathsf{info}(\varphi)$, if a comes in w, then John will invite a for dinner, if b comes, John will invite b, etc. Meanwhile, the description we just gave indicates that φ cuts across all the alternatives in the question 'who comes?' (a comes, b comes, etc.), hence the resulting proposition φ is indeed orthogonal to the antecedent question. Moreover, this change on the location of orthogonality will not affect the result we get for unconditionals without binding between antecedents and consequents. Consider again the sentence 'No matter where the party will be, John may go'. It is shown above the semantic output of the whole sentence is 'John may go to the party' (the same as the consequent), as illustrated in Fig. (2.1d), thus the orthogonality result remains intact. Later, it will be clear that the modification regarding the locus of orthogonality is crucial for its manifestation in ∀-FC constructions, as the 'antecedent' and 'consequent', as will be retrieved in an unconditional analaysis for ∀-FC constructions, are merged into a single (basic) clause.

The final technical piece before we move to ∀-FC constructions is an extension of the definition of orthogonality from Partition Semantics to Inquisitive Semantics. With possibly overlapping alternatives (consider again two alternatives I_1 and I_2), merely intersecting their alternatives as in (2.12) doesn't seem to suffice. Consider $I_1 = \alpha \vee \beta$ a question with overlapping alternatives α and β, as shown in Fig. (2.2a). If I_2 is the non-inquisitive issue whose informative content consists of only the $\alpha \wedge \beta$ world, then although I_2 intersects with both alternatives in I_1, they are not orthogonal (I_2 even resolves I_1). An issue I_2 that is orthogonal to I_1 should take the shape as the dashed area in Fig. (2.2b), namely, any alternative of I_2 wouldn't help in (even partially) resolve the issue I_1.

(a) (b)

Figure 2.2: Orthogonality in Inquisitive Semantics: Intuition

Based on the above observations, we define orthogonality in terms of inquisitive semantics as in (2.13). The definition follows directly from the informal layout that any resolution of either issue wouldn't even partially resolve the other one.

Definition 2.13. (Orthogonality: in Inquisitive Semantics)

Given a world domain W, two issues $I_1, I_2 \subseteq \wp(W)$ are *orthogonal* relative to a context c if and only if:

- For all $p_1 \in \mathsf{alt}(I_1)$, there is no $p_2 \in \mathsf{alt}(I_2)$ s.t. $p_1 \subseteq p_2$, and for all $p_2 \in \mathsf{alt}(I_2)$, $p_1 \cap p_2 \neq \emptyset$;
- For all $p_2 \in \mathsf{alt}(I_2)$, there is no $p_1 \in \mathsf{alt}(I_1)$ s.t. $p_2 \subseteq p_1$, and for all $p_1 \in \mathsf{alt}(I_2)$, $p_2 \cap p_1 \neq \emptyset$.

Let's turn to ∀-FC constructions. As mentioned before, the structural similarity between Mandarin ∀-FC constructions (3) and unconditionals (42) suggests a parallel treatment. However, in Mandarin ∀-FC constructions, the argument position of the unconditional head '*wúlùn*' is occupied by a *wh*-phrase instead of an antecedent question[12]. To retrieve the antecedent question, we treat the *wh*-phrase as an *identity question* w.r.t. a type *e* variable *u* (written as '**?**u'), which will subsequently fill in a vacuous argument position in the following VP predicate and retrieve the consequent. As a result, a Mandarin ∀-FC sentence is reconstructed into an unconditional with a binding relation between the antecedent and the consequent. As an empirical support for such treatment, we observe that the Mandarin copula '*shi*', which can be used to impose a (real) identity question as in (52a), can often be inserted between '*wúlùn*' and the *wh*-phrase as in (52b):

[12]We can also view *ren-he* as a lexicalized 'no matter what' construction, as '*ren*' has the reading of 'no matter', and '*he*' of 'what'.

(52) a. Ta shi shui?
He BE who
'Who is he?'

b. Wúlùn shi shui dou keneng yu-dao mafan.
No-matter BE who **dou** may run-into trouble
'Anyone can run into trouble.'

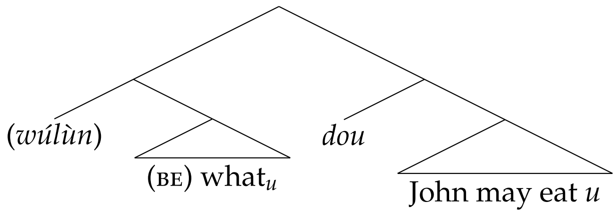
The semantic derivation of ∀-FC constructions is now in place. First, the identity question **?**u can be formally characterized as follows:

(53) **?**$u := \forall x \in D.\,?(u = x)$, where D is the domain of (possibly plural) individuals, and $?(u = x) := (u = x) \vee (u \neq x)$.

We will, for the time being, assume that the identity of u is a piece of world information that helps pin down the actual world (after introducing the framework of Dynamic Inquisitive Semantics, the identity of u will be stored in discourse information, see §4.1). Now take the sentence (3a) (repeated below in (54)) as a working example, the unconditional analysis proceeds as follows:

(54) (Wúlùn) [shenme] shuiguo Yuehan *(dou) keyi chi.
(no-matter) what fruit John **dou** may eat.
'John may eat any fruit.'

a. Assuming the following toy structure:

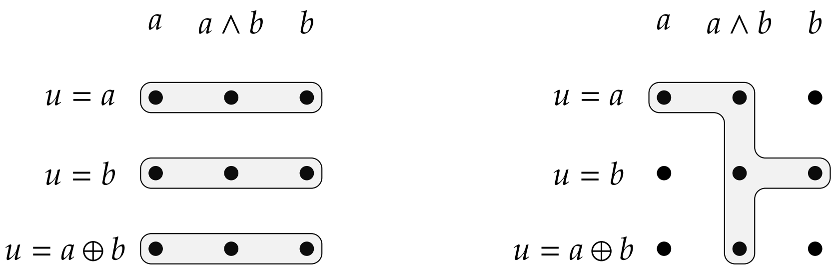


b. $[\![$(BE) what$_u]\!] =$ **?**u
Suppose the domain of individuals D consists of two atomic members a, b that are fruits, along with their plural sum $a \oplus b$, then the semantics of the identity question **?**u can be visualized as in Fig. (2.3a).

c. $\varphi(u) := [\![$John may eat $u]\!] = \lambda s_{st}.\,\forall w \in s : \exists w' \in \mathrm{MB}_d(w)$.John eat u at w'

d. Apply the semantics of dou_Q (49), we get the following semantic representation of (3a):
$[\![(3a)]\!] = [\![dou_Q]\!](\mathbf{?}u)(\varphi(u)) = \mathbf{?}u > \varphi(u)$, defined only if
- $|\mathsf{alt}(\mathbf{?}u)| > 1$ (inquisitiveness)
- $\mathsf{info}(\mathbf{?}u) = c$ (exhaustivity)

Let $a, b, a \wedge b$ represent the world information that 'John may eat a', 'John may eat b' and 'John may eat a and b', respectively, and assume the context to contain all black dots, the result is shown in Fig. (2.3b).



(a) $?u$ (b) $?u > \varphi(u)$

Figure 2.3: Derivation of the ∀-FC reading

Note that Fig. (2.3b) depicts exactly the ∀-FC reading we want. The result (denoted as ψ) is non-inquisitive, and for any world $w \in \mathsf{info}(\psi)$, if $u = a$ in w, then John may eat a at w, etc., hence the free choice effect. Moreover, a comparison between Fig. (2.3a) and Fig. (2.3b) demonstrates that the resulting proposition is indeed orthogonal to the identity question, as the only alternative of the former intersects with all the alternatives with the latter.

To briefly summarize, we show in this section that the semantic contribution of unconditionals and ∀-FC constructions can be uniformly conceptualized as conveying *orthogonality*, and how ∀-FC reading can be formally captured adopting an unconditional analysis. Meanwhile, as the reader might have noticed, the section shows a strong appeal to a dynamic treatment, especially due to the 'donkey'-like unconditional (51) and the analogous reconstruction for ∀-FC sentences. The dynamic transition will eventually be done in Chapter 4, and it will provide a novel perspective in which the structural similarity between *plurality* and *inquisitiveness*, both of which related closely to *dou*, displays as certain indeterminacy of the context.

2.3 *Dou* as Scalar Marker

Let's turn to the last major use of *dou*, i.e. as a *scalar marker* that gives rise to an '*even*' reading when associated with a focused item and an optional prepositional particle '*lian*' which usually means 'connect, along with'. The basic data (4) is repeated here:

(4) a. (Lian) [Yuehan]$_F$ dou chi -le yi-ge niuyouguo.
(LIAN) [John]$_F$ **dou** eat -ASP one-CL avocado.
'Even John ate an avocado.'

b. Yuehan (lian) [yi-ge niuyouguo]$_F$ dou mei gei wo sheng.
John (LIAN) [One-CL Avocado]$_F$ **dou** not give me leave.
'John didn't leave me even one avocado.'

In addition, we observed in (5) that *dou* associates with in-situ scalar items (without '*lian*') and indicates its high ranking on a contextually relevant scale:

(5) a. Yuehan dou chi -le [ba-ge]$_F$ niuyouguo -le.
John **dou** eat -ASP [eight-CL]$_F$ avocado -ASP.
'John's already eaten Eight avocados.' ⇝ *eight avocados are a lot.*

b. Tian-tian chi niuyouguo, ta dou chi [ni]$_F$ -le.
Day-day eat avocado, he **dou** eat [Tired]$_F$ -ASP.

'Eating avocados everyday, he's rather Tired of it.'
⇝ *Being tired of eating avocados suggests a lot of avocado-eating.*

c. (Zhe) dou [wu dian]$_F$ -le. (Xiang, 2018)
(This) **dou** [five o'clock]$_F$ -ASP.
'It's five o'clock already!' ⇝*five o'clock is quite late.*

Unlike in the ∀-FC construction '*(wùlùn)...wh...dou*', the *even*-like meaning of '*lian* Foc *dou*' seems rather distant from the distributivity effect. Perhaps as a result, many existing approaches deviated from Lin (1998) in order to reach a uniform analysis for *dou*. As a (rather extreme) example, Liu (2017) equalized the semantics of *dou* with English *even*, and claimed that the distributor use of *dou* is the result of the *even* meaning being *trivialized* by a distributive operator (see §1.3.3 for details). We repeat his entry for *dou* here for convenience.

(14) Semantics of *dou* (Liu, 2017)

$$[\![dou]\!] = \begin{cases} \lambda p_{\langle s,t\rangle}\lambda w_s.\, p(w) = 1 & \text{if } \forall q \in [\![p]\!]_F[q \neq p \rightarrow q >_{\text{likely}} p] \\ \text{undefined} & \text{otherwise} \end{cases}$$

We suspect this approach should be disfavored from a diachronic perspective (Chen, 2018; Gu, 2015), as it is reported that the scalar use of *dou* comes long after the distributive use[13]. Set historical issues aside, this approach presupposes that *dou* contributes to the *even* reading all by itself. Yimei Xiang (2018) has the same assumption, though differing from Liu as she claims the *even*-like use to be secondary to the distributor use, and is obtained by *weakening* the sub-alternative semantics from logical entailment to likelihood. In response, we will start this section by arguing that *dou* doesn't carry the whole load here. We then suggest a new account in which the contribution of *dou* is in fact a *scalarized* distributivity effect, and the *even*-like reading follows from a coordination of the focused item (with a scalar feature [+σ]). As we will see, the new account takes key inspirations from Ming Xiang (2008) and Yimei Xiang (2018).[14]

2.3.1 *Dou* is not *even* alone

(Ming Xiang, 2008, p. 243) connected the '(*lian*) Foc *dou*' construction with a very similar combination '(*lian*) Foc *ye*' in Mandarin. '*Ye*' is commonly used as a focus-sensitive additive particle (translated as *also*/*too*) by itself:

(55) Ta chi -le yi-ge niuyouguo, [wo]$_F$ ye/*dou chi -le yi-ge.
She eat -ASP one-CL avocado, [I]$_F$ **ye**/***dou** eat -ASP one-CL.
'She ate an avocado, and so did I.'

Note that '*ye*' cannot be replaced by *dou* in (55). On the other hand, when combined with a focus item and '*lian*', it gives rise to the *even*-like reading as *dou*, and they are almost interchangeable:

(56) Yuehan (lian) [yi-ge niuyouguo]$_F$ ye/dou mei gei wo sheng.
John (LIAN) [One-CL Avocado]$_F$ also/**dou** not give me leave.
'John didn't leave me even One Avocado.'

[13]According to Gu (2015), the distributor use of *dou* emerged as early as the Eastern Han Dynasty (25AC - 225AC) in Old Chinese, whereas Chen (2018) reported that the scalar use of *dou* didn't show up until around the time of Early Mandarin (from Ming Dynasty, around 1368AC and on).

[14]Special thanks to Alexandre Cremers for providing the core elements of the solution.

Such similarity would be very puzzling if we assign the *even* meaning solely to *dou*. If we do so, then due to the parallel constructions it seems sensible to also assign the *even* meaning to *ye*. However, the plain additive reading of *ye* cannot be retrieved in the same way as the distributive reading of *dou*. To see this, we assume the following semantics (57) of focus-sensitive additive particles such as *also* or *too* (Rullmann, 2003)[15]. In the definition they are simply taken as propositional operators that take focused propositions (written as φ_{F}) as arguments.

(57) Semantics of plain additive particles:

$$[\![also/too\ \varphi_{F}]\!] = \begin{cases} [\![\varphi]\!] & \text{if there is } \psi \in [\![\varphi]\!]_{F} \text{ s.t. } \psi \neq \varphi \text{ and } \psi \text{ is true} \\ \text{Undefined} & \text{otherwise} \end{cases}$$

Plain additive particles are semantically vacuous, but presuppose the truth of some other alternatives w.r.t. their prejacents. Recall that Liu (2017) proposed that the distributive reading of *dou* is generated by a covert distributive operator DIST, and it further *trivializes* the *even* meaning of *dou*. The key component of the trivialization is the Entailment-Scalarity Principle (Crnič, 2011, 2014), i.e. a logically weaker proposition is more likely to be true. Now that the truth of the sub-parts generated by DIST is entailed by, hence more likely than its prejacent, the presupposition of *dou* as in (14) is automatically satisfied, and the distributive reading is viable. However, the semantics of plain additive particles as in (57) doesn't seem to support or be supported by the semantics of *even* as in (14). First, the presupposition given in (57) requires the *truth* of another alternative, which is not necessary according to the presupposition of *even*. Meanwhile, the alternative (and any other ones that are not necessarily true) can very well be as (un)likely as the prejacent, contrary to the likelihood requirement imposed by *even*. Therefore, we suggest that the semantics of the additive particle *ye* should contribute to, but be relatively independent from the *even*-like reading of '*lian* Foc *dou*/*ye*' construction.

Another argument against *dou* carrying all the load of *even* concerns the semantics of *lian*. When *lian* is used as a preposition governing non-focused items, its adjacent expression must carry some marginality features, as shown by the contrast below:

(58) a. Ta ba zheng-ge niuyouguo lian hu yiqi tun -le.
He BA whole-CL avocado LIAN core together swallow -ASP.
'He swallowed the whole avocado, along with the core.'

b. *Ta ba zheng-ge niuyouguo lian guorou yiqi tun -le.
He BA whole-CL avocado LIAN fruit together swallow -ASP.
'*He swallowed the whole avocado along with the fruit part.'

Contrary to the infelicitous association with '*guorou*/fruit', since '*hu*/core' is usually not the swallowed part of an avocado, it can be associated with *lian*. Therefore, *lian* must be producing certain scalar effects by itself. Ming Xiang (2008) adheres to this idea and makes '*lian*' responsible for the scalar reading. She claims that *lian* not only asserts the truth of its focused prejacent, but also introduces a scale about *unexpectedness* w.r.t. the alternative set. Meanwhile, since *dou* is defined as a maximality operator in her account, it ensures that its associate is the unique element with the maximal degree on the scale. Her entry of *lian* (combined with a focused item α of type e) is the following:

[15]One important question in the literature on *too* is anaphoricity. It looks like *too* not only requires that a focus alternative is true, but also requires an available discourse referent. This dynamic component is not addressed in our account, but it wouldn't affect the following reasoning.

(59) Semantics of *lian*: Ming Xiang (2008)

$$[\![lian\ \alpha_F]\!] = \lambda P_{\langle e,st\rangle}\lambda w_s.\ P(\alpha)(w) = 1 \wedge$$
$$\exists\beta \in [\![\alpha]\!]_F[\beta \neq \alpha \wedge P(\beta)(w) = 1] \wedge$$
$$\forall\beta \in [\![\alpha]\!]_F : P(\beta)(w) = 1 \rightarrow \textsc{unexp}(P(\alpha))(w) > \textsc{unexp}(P(\beta))(w)$$

It is quite clear then how the *even*-reading of the '*lian* Foc *dou*' construction comes about. With the first line giving the truth condition, the second line of the definition, i.e. the assertion of the truth of an alternative β to the focus item α w.r.t. the predicate P, corresponds to the plurality presupposition of *dou*, and the third line provides a scale on which *dou* as a maximality operator is supposed to pick out the unique element occupying the maximal degree of unexpectedness. This account seems to capture the *even*-reading of '*lian* Foc *dou*' construction quite completely. Moreover, with the scalar information carried by *lian*, Ming Xiang is able to make predictions about the subtle differences between '*lian* Foc *dou*' and '*lian* Foc *ye*' constructions based on the basic semantics of *dou* and *ye*. For example, as a maximality operator, *dou* is preferred in the context where the speaker intends to emphasize exhaustivity. As shown in (60a), with the intended reading emphasizing the fact that 'everyone knows', *dou* is much more preferred. On the other hand, with a contrastive sentence emphasizing the fact that some other alternatives are true without an obvious intention of exhausting all the other alternatives, as in (60b), '*lian* Foc *ye*' is also acceptable (if not preferred).

(60) a. Lian [shagua]$_F$ dou/?ye zhidao zhege.
LIAN [Idiot]$_F$ **dou**/?**ye** know this.
'Even Idiots know this.' (Xiang, 2008, same for b.)

b. Wo zhi rang ta dasao fangjian, dan ta lian fan dou/ye shao -hao -le.
I only ask him clean room, but he LIAN meal **dou**/**ye** cook -done -ASP.
'I only asked him to clean the room, but he even cooked the meal.'

We think the analysis is on the right track, but still problematic in the following aspects. First, (59) encodes into the semantics of *lian* the truth of some other alternatives in order to satisfy the plurality requirement of *dou* w.r.t. its associates. It is not necessary here, and perhaps even undesired. Consider the following scenario:

(61) *Scenario: John is hosting a singing competition, and he made every effort to invite a phenomenal singer, Jay, as the judge for the finals. John asked the contestants to arrive an hour early for preparation. On the day of the finals, to John's great surprise, no contestant showed up on time, even after Jay arrived at the set just a few minutes before the designated starting time. Poor John asked his assistant anxiously...*

Lian [Jay]$_F$ dou dao -le, xuanshou-men dou qu na -le?
LIAN [Jay]$_F$ **dou** arrive -ASP, contestant-PL dou go where -ASP?

'Even Jay is here, where are all the contestants?'

As shown in (61), even though John knows that no contestant showed up, it is still acceptable to assert the sentence '*lian* [Jay]$_F$ *dou* come'[16]. Therefore the truth of some

[16]Careful readers might have noticed that there is another *dou* in the subsequent question. We will not address the behavior of *dou* in questions in this thesis, but for now it can be understood as stressing the speaker's astonishment of the contestants not being 'here'.

other alternative is not required for '*lian* Foc *dou*' constructions. Bad news is, we cannot simply remove this condition or substitute it to a weaker one. For instance, it might be tempting to try out the following revised definition of *lian*:

(62) Semantics of *lian*: revised

$$[\![lian\ \alpha_F]\!] = \lambda P_{\langle e,st\rangle}\lambda w_s.\ P(\alpha)(w) = 1 \wedge$$
$$\exists\beta \in [\![\alpha]\!]_F[\beta \neq \alpha] \wedge$$
$$\forall\beta \in [\![\alpha]\!]_F : P(\beta)(w) = 1 \rightarrow \text{UNEXP}(P(\alpha))(w) > \text{UNEXP}(P(\beta))(w)$$

Note that (62) weakens the second line of (59) by only asserting the existence, instead of truth, of some other alternatives. However, such definition cannot rule out the case where $P(\alpha)$ is the only true alternative at w in the set $[\![P(\alpha)]\!]_F$, and it is also the least unexpected (most likely) one. What about getting rid of the conditional antecedent '$P(w)(\beta) = 1$' in the third line? This change would indeed prevent the case where α is the least unexpected, but it imposes the strong requirement that α is the *most* unexpected alternative w.r.t. P. However, the '*lian* Foc *dou*' construction doesn't seem to involve such maximality either, as the following example suggests:

(63) Su lian [yazhou guanjun]$_F$ dou na -le, jiu cha yi-ge shijie
Sue LIAN [Asia Championship]$_F$ **dou** get -ASP, only lack one-CL world
guanjun -le.
championship -ASP.
'Sue has even won an Asian championship, only one world championship to go.'

Just as Bennett (1982) and Kay (1990) suggested for *even*, '*lian* Foc *dou*' construction doesn't need to associate with the (contextually) most unexpected/unlikely alternative, like the 'world championship' in the above example. On the other hand, it does only associate with the most unexpected *true* alternative, as captured by the third line of (59) and (62). For instance, in a context where Sue has already won a world championship, the following utterance is not acceptable:

(64) *Scenario: Sue has already won a world championship.*

*Su lian [yazhou guanjun]$_F$ dou na -le.
Sue LIAN [Asian Championship]$_F$ **dou** get -ASP.

*'Sue has even won an Asian championship.'

Therefore, at least some technical modifications to (59) need to be made to capture the above mentioned features of '*lian* Foc *dou*' constructions. The proposal given in the next section will take an intermediate position between Liu (2017) and Yimei Xiang (2018), where the labor is divided between *lian* and *dou* in the derivation of the *even*-like reading. In particular, *lian* will behave like an abstract filter, whose scalar effect is transferred to *dou*, which in turn distributes it over the focus set.

2.3.2 The Proposal: Distributivity *Scalarized*

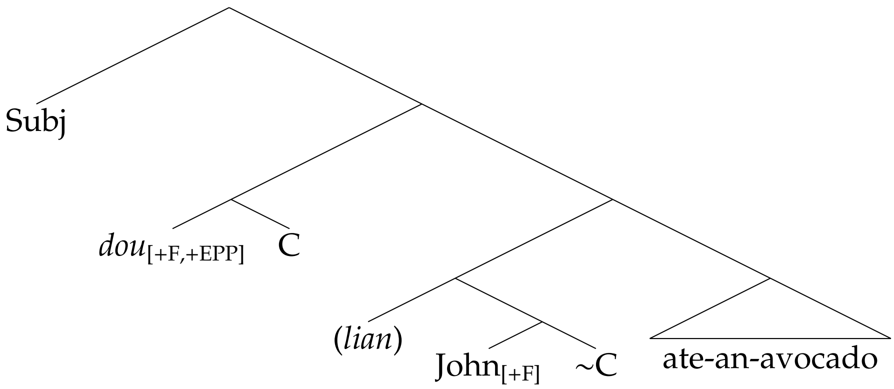
Let's start with the semantics of *lian*. Judging from the data given in (58), *lian* is a preposition of type $\langle e, \langle\langle e,st\rangle, \langle e,st\rangle\rangle\rangle$, namely, it takes an entity and forms a predicate modifier. When used as a preposition as in (58), *lian* takes a type *e* argument and returns a predicate modifier - mapping a predicate to a new one. We assume that when it is associated with focus items, it still takes in a predicate as argument, but instead of directly producing a modified predicate, it has a more 'abstract' semantics and yields a general property that will be later imposed on each element in the focus set generated by its focused associate. The entry is given as follows:

(65) $[\![lian(\alpha_{F})]\!] = \lambda P_{\langle e,st\rangle}\lambda\beta_e\lambda w_s.\ [\beta = \alpha \wedge P(\beta)(w) = 1] \vee$
$[\beta \neq \alpha \wedge P(\beta)(w) \rightarrow \text{UNEXP}(P(\alpha))(w) > \text{UNEXP}(P(\beta))(w)]$

Given (65), the resulting 'abstract' property carries the scalar feature inherited directly from Ming Xiang (2008), except that it doesn't function directly on the focus set $[\![\alpha]\!]_F$. In order to instantiate this property, it requires the presence of an operator, e.g. *dou* or *ye*, that can operate on the focus set. Thus the proposal also (in)directly accounts for the obligatory presence of *dou* or *ye* in an *even*-like sentence.

Now let's incorporate the analysis of *dou* into the scalar construction. Since we hope to stick to the idea that *dou* requires plurality and expresses distributivity, it is crucial to make sense of the roles these two features play. Taking (4a) as a working example (repeated below in (66)), the following structure is assumed:

(66) (Lian) [Yuehan]$_F$ dou chi -le yi-ge niuyouguo.
(LIAN) [John]$_F$ **dou** eat -ASP one-CL avocado.
'Even John ate an avocado.'



We assume that *dou* here also carries [+F] in order to check off the [+F] feature carried by the focused phrase. The [+EPP] feature (Chomsky, 2014) is checked off by moving its associate NP to the specifier position on its left[17]. Since the [+EPP] feature only results in the movement of NP, it then explains the co-occurrences of in-situ focused VPs with *dou*, as exemplified in (5). Following Rooth (1992), we assume a focus operator '∼' operating on a focus variable C (construed as a set of alternatives) generated by the focused item 'John$_F$' and provide contextual restrictions. The focus variable *C* is then bound by *dou*. Following Rooth (1992), we assume ∼ imposes the following restriction on *C*:

(67) (i) $[\![\text{John}]\!] \in C$
(ii) $C \subseteq [\![\text{John}]\!]_F$

Namely, it is a subset of the focus set $[\![\text{John}]\!]_F$ that contains the ordinary value. Now let's see how *dou* works. We assume the plurality requirement of *dou* is directly imposed on C. This results in the requirement that besides the ordinary value $[\![\text{John}]\!]$ (enforced by (67i)), there is at least one other individual in *C*. What about the distributivity effect?

[17]It is commonly assumed that *dou* carries the [+EPP] feature all along, thus explains the *leftness* condition of *dou* (Lin, 1998), i.e. when it's used as a distributor, its associate NP always appear on its left.

First we observe that the scalar reading of *dou* probably developed from its original distributivity effect. (Chen, 2018, p. 125-126) reported that the scalar use of *dou* emerged in Early Chinese associating to 'one'-phrase minimizers in negative context:

(68) [Yi li]$_F$ dou bu jie.
[One UW]$_F$ **dou** not lend.
'(He) didn't lend me even One UW.'
(Chen, 2018, from *Ancient Sinica Corpus*, *li*/UW is a small currency unit.)

Associating with minimizer constructions, the distributivity effect of *dou* is clearly compatible - if the addressee didn't lend even one UW to the speaker, it is clearly the case that he didn't lend the speaker any higher amount of money. In this case, the distributivity effect successfully complies with the truth of all the other alternatives. However, as already shown in (61), the *truth* of all the alternatives is too strong to get the correct reading. Therefore we assume the distributivity effect of *dou* is assimilated by the scalar reading of its focused associate (or *scalarized*). We model such assimilation as *dou* inheriting the abstract propositional-level property generated by *lian*, and distributes it over the actual alternative set ~ C. The final entry of *dou* as a scalar marker, written as dou_σ, is given in (69).

(69) Semantics of dou_σ
$$[\![dou_\sigma]\!] = \lambda C_{\langle e,t\rangle}\lambda \mathcal{P}_{\langle e,st\rangle}\lambda w_s.\ \underbrace{|C| > 1}_{\text{plurality}}.\ \underbrace{\forall \beta \in C : \mathcal{P}(\beta)(w) = 1}_{\text{distributivity effect } scalarized}$$

A complete derivation of the structure (66) is then in order. Here we list the key steps:

(70) a. $[\![\text{John}]\!] := j_e$, $[\![\text{ate-an-avocado}]\!] := \lambda x_e \lambda w_s.\ [\mathbf{E\text{-}a\text{-}A}(x)(w) = 1]$
b. $[\![lian(\text{John}_F)]\!](\text{ate-an-avocado})$
$= \lambda \beta_e \lambda w_s.\ [\beta = j \wedge \mathbf{E\text{-}a\text{-}A}(\beta)(w) = 1] \vee$
$[\beta \neq j \wedge \mathbf{E\text{-}a\text{-}A}(\beta)(w) \rightarrow (\text{UNEXP}(\mathbf{E\text{-}a\text{-}A}(\beta))(w) < \text{UNEXP}(\mathbf{E\text{-}a\text{-}A}(j))(w)]$
c. $[\![(4a)]\!] = [\![dou_\sigma]\!]([\![lian(\text{John}_F)]\!](\text{ate-an-avocado}))$

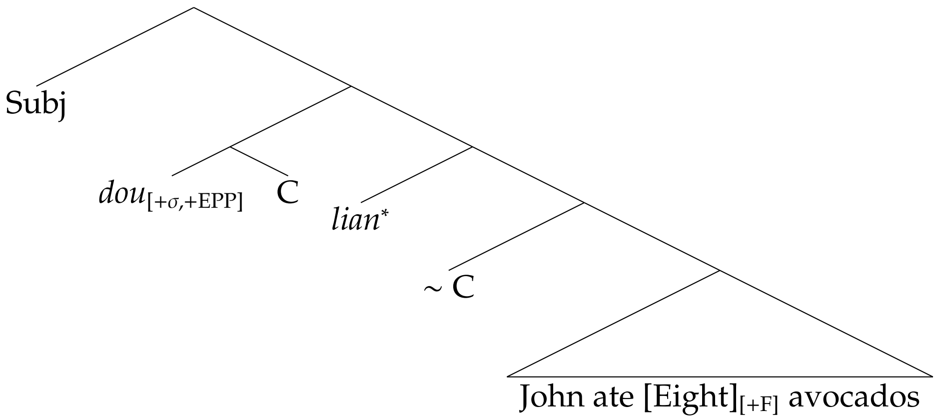
The final outcome (70c) gives the desired interpretation, namely, there is someone other than John that is more likely to eat an avocado, and all the other people who actually ate an avocado are more likely than John to do so. Unluckily, as *dou* only requires the plurality of *C*, it is not guaranteed that *C* contains a more likely alternative than John (all the other alternatives can be less likely than John to eat an avocado but didn't). Here we explain it via a general *economy condition*—that an overt operator cannot be applied vacuously (cf. Chierchia, 1998). Therefore, for *lian* (or the focus item) to be overtly uttered, it has to be the case that there is at least one less unlikely alternative.

The analysis can be easily extended to capture *dou*'s association with the in-situ focused predicates, if we assume there is a silent scalar operator, say '*lian**', that does the same job as '*lian*', but is associated with focused propositions[18]. Consider the following structure for sentence (5a) (repeated below in (71)):

(71) Yuehan dou chi -le [ba-ge]$_F$ niuyouguo -le.
John **dou** eat -ASP [Eight]$_F$ avocado -ASP.

[18] Here we follow the VP-internal subject hypothesis (Kitagawa, 2018; Fukui and Speas, 1986, a.o.) and assume the subject is generated inside VP, combined with *lian** and after that moved to the specifier position and checks off the [+EPP] feature of *dou*.

'John's already eaten Eight avocados.' ⇝ *Eight avocados are a lot.*



Meanwhile, we assume the following semantic contribution of *lian**:

(72) $[\![lian^{*}\ \varphi]\!] = \lambda p_{st} \lambda w_s.\ [p = \varphi \wedge p(w) = 1] \vee$
$$[p \neq \varphi \wedge p(w) \rightarrow \textsc{unexp}(\varphi)(w) > \textsc{unexp}(p)(w)]$$

*lian** then differs with *lian* only in that it takes a focused proposition directly as argument, and returns a propositional-level 'abstract' property. Accordingly, the semantic function of *dou* should be accommodated for the scalarization. We write this *dou* as dou^{*}_{σ} to distinguish from dou_{σ}, and the entry is given as follows:

(73) $[\![dou^{*}_{\sigma}]\!] = \lambda C_{\langle st,t \rangle} \lambda \mathcal{T}_{\langle st,st \rangle} \lambda w.\ \underbrace{|C| > 1}_{\text{plurality}}\ .\ \underbrace{\forall p \in C : \mathcal{T}(p)(w) = 1}_{\text{distributivity effect } scalarized}$

The final reading of (5a)/(71), following similar steps in (70), will be that John ate eight avocados, and it is more likely to eat less, indicating that eight avocados are a lot.

To briefly conclude, we have shown in this section that the *even*-reading of *dou* in '*lian* Foc *dou*' construction is not primary in the semantics of *dou*, nor should it be isolated from its original distributive reading. We proposed the notion of *scalarized* distributivity, based on which a compositional analysis of the scalar construction is developed, in which the plurality requirement and the distributivity effect of *dou* both play important roles.

CHAPTER **3**

Dynamic Inquisitive Semantics

The previous chapter has layed out a 'static' analysis of the Mandarin particle *dou*, where it is demonstrated that its diverse semantic uses can be uniformly explained in terms of a *distributivity effect* paired with a *plurality requirement*. One thing remained unexplained is why they can operate on seemingly rather different linguistic objects - definite plurals/generalized quantifiers, questions, and focus set. In the next two chapters, we tackle this problem by denying it - viewing through the lens of Dynamic Semantics (Kamp, 1981; Heim, 1982; Groenendijk and Stokhof, 1991) where propositional meanings are characterized as *Context Change Potentials*, we claim that the *plurality requirement* of *dou* can be construed as imposing *Contextual* indeterminacy. The idea gets inspiration from a meta-theoretical observation. After the emergence of the first-order dynamic system of Groenendijk, Stokhof and Veltman (1996) (referred to as GSV), two major threads towards its enrichment concern the incorporation of **questions** (Groenendijk et al., 1998; van Rooij, 1998; Haida, 2008, a.o.) and **pluralities** (van den Berg et al., 1996; Brasoveanu, 2008, a.o.), pointing directly to the associations of *dou*. In addition, dynamic semantics provides a natural treatment of (un)conditionals with donkey anaphoras as in (51), which is problematic for the static analysis of Rawlins (2013) yet crucial for the derivation of FC reading. Stepping towards more uniformity of the analysis of *dou*, the chapter will dedicate to a step-by-step introduction of the framework of Dynamic Inquisitive Semantics ($\mathsf{Inq}_{\mathrm{D}}$) (Dotlačil and Roelofsen, 2019) that combines the treatments of questions and pluralities. Then in the next chapter, we apply the $\mathsf{Inq}_{\mathrm{D}}$ framework to 'upgrade' the previous formalization of *dou*, spelling out how exactly the context, as conceptualized in the dynamic system, is involved in the evaluation.

3.1 Updating Context

As is mentioned in the chapter head, Dynamic Semantics characterizes propositional meanings as *context change potentials*. A natural formalization of this idea, then, is to model the semantic value of a sentence as a function that maps an input (background) context to a new output one. In this section, therefore, we give an incremental introduction of how contexts are formally defined in $\mathsf{Inq}_{\mathrm{D}}$, and how they can be conceptually construed.

3.1.1 Context in GSV

Dynamic Semantics was first motivated by the urge to store and retrieve an extra piece of discourse information, namely the information about *discourse referents*, in order to account for cross-sentential/donkey anaphoric bindings. A *discourse referent* (dref) is typically introduced by indefinite NPs and referred back to by definite ones. In order to model a notion of context that not only carries the world information in a traditional static sense, but also the discourse information about dref, GSV defines a context as a set of world-assignment pairs $\langle w, g \rangle$, where w is a possible world and g is an assignment function mapping every dref that are introduced previously to an individual. Then a context C captures the world information by restricting the actual world in the domain of the set of worlds w that can be *projected* from an element in C (there is a world-assignment pair $\langle w', g \rangle \in C$ such that $w = w'$), as well as the dref information by restricting the individuals that *can* be referred to in the functional domain of some g *projected* from an element $\langle w, g \rangle$ in C. In particular, world information and dref information in a context C interact through discourse *conditions*. To be specific, given some *conditions* on a dref u established in C (we refer to such dref as *active*), C can only contain world-assignment pairs $\langle w, g \rangle$ where the condition is satisfied by the individual denoted by $g(u)$ at w. As a result, a discourse structure, usually referred to as a discourse representation structure (DRS), is usually described as a combination of a set of discourse referents and a set of conditions. It will be clear later that it serves as an (intermediate) translation between natural language sentences and logical propositions.

The GSV definition of context is a starting point for the subsequent enrichments, which are all, as we will see, set-theoretic *liftings* of the basic notion of world-assignment pairs. §3.1.2 starts the process with the (Compositional) Discourse Representation Theory with Plurals (PCDRT, per Brasoveanu, 2008, 2012) in which the single assignment g is lifted to a set of assignments G to capture quantificational dependencies between sets of objects. The idea of lifting possible worlds up to a set of downward-closed information states, introduced by $\mathsf{Inq_B}$ as in §2.2.1.1, is then applied in §3.1.3 to yield the final definition of contexts in $\mathsf{Inq_D}$ that captures the dynamics of questions.

3.1.2 Context in PCDRT

Dynamic Plural Logic (van den Berg et al., 1996), followed by PCDRT, started with the observation that anaphoric linkings require a more general characterization. The set up of the GSV context assumes an assignment function g to specify a *single* instantiation of each active dref u. However, anaphoric bindings can happen between plural expressions, as shown in (74a), and even between an anaphora and multiple antecedents, as in (74b). Here the superscript u signals the antecedent introducing a new dref u, whereas the subscript u signals the anaphor retrieving an active u.

(74) a. Some^u people are eating avocados. They$_u$ are laughing.
b. John$_{u_1}$ and Mary$_{u_2}$ are eating avocados. They$^u_{u_1 \oplus u_2}$.

Enabling the assignment function g to have plural individuals in its co-domain solves the problem here, but it wouldn't be of much help, as *quantificational dependencies* among sets of objects can be established, and subsequently elaborated upon in the discourse.

(75) Linus bought a^u gift for every$^{u'}$ girl in his class and asked their$_{u'}$ deskmates to wrap them$_u$. (Brasoveanu, 2008, p. 130)

The universal quantifier *every*$^{u'}$ in the first conjunct establishes a quantificational dependency between each girl u' in the class and the gift u bought to them by Linus. Such dependency is further elaborated in the subsequent conjunct s.t. each u'-girl's deskmate was asked to wrap the corresponding gift u. If each active dref u only has a single (possibly plural) instantiation via a single assignment function g, the internal correlation between u and u' as in (75) is very hard (if possible) to establish, let alone being retrieved and elaborated. Furthermore, Brasoveanu observed that the quantificational dependency between plural individuals can be invoked even without morphologically plural anaphora:

(76) Every^{u} person who buys a$^{u'}$ book on amazon.com and has a$^{u''}$ credit card uses it$^{u''}$ to pay for it$^{u'}$. (Brasoveanu, 2008, p. 130)

Brasoveanu (2008) thus proposed to capture quantificational dependencies through a generalization of the assignment function g via Dynamic Plural Logic, namely, instead of a single assignment function g providing a single instantiation of each dref, PCDRT takes a set of assignments G so that each dref u may correspond to a set of instantiations. Such sets of assignment G are referred to as assignment *matrices*, due to the following matrix display (77) of its functional value.

(77)

G	u	u'	u''	$\cdots$
g_1	a	a'	a''	
g_2	b	b'	b''	
g_3	c	c'	c''	
$\cdots$				

(77) exemplifies an assignment matrix G with elements $\{g_1, g_2, g_3, ...\}$ assigning individuals to active drefs $\{u, u', u''...\}$. In addition, we require that the domain of each assignment function g_i in a assignment matrix G to be the same, i.e. the set of active drefs. Such two-dimensional structure enables (i) each dref to store a set of individuals, thus being able to be referred to by a plural expression as in (74a), and (ii) a *distributive* description of structural dependencies among drefs - the individuals assigned to u, u', u'' etc. by a single assignment function g_i are structurally correlated. For instance, when interpreting sentence (76), $g_i(u), g_i(u'), g_i(u'')$ $(i = 1, 2, 3, ...)$ refers to a person, the book he/she buys on amazon.com, and the credit card he/she used to pay for the book, resp. Based on the notion of assignment matrices, Brasoveanu (2008) further distinguishes between a *plural reference* and a *plural discourse reference*. A *plural reference* w.r.t. a dref u requires domain-level plurality in that given an assignment matrix G, for each $g \in G$, $g(u)$ is non-atomic. In particular, a plural reference can (but not necessarily) be obtained via a sum of multiple drefs, as in (74b). On the other hand, *plural discourse reference* accepts domain-level atomicity, but requires the sum of the individuals assigned to the dref to be non-atomic. Domain-level and discourse-level singularity can be defined in parallel. Typically, domain-level singularity/plurality can be enforced by singular/plural cardinal indefinites such as '*A boy*'/'*two boys*'. Singular morphologies also enforces domain-level singularity, yet it's not necessarily the case for plural counterparts (e.g. in sentence (75), morphologically plural *their*$_{u'}$ and *them*$_{u'}$ refer back to domain-level atomic drefs).

Based on the generalization introduced above, we can now lift the element in the context set from world-assignment pairs $\langle w, g\rangle$ to world-assignmentS pairs $\langle w, G\rangle$ where G is an assignment matrix. Following Dotlačil and Roelofsen (2019), we will refer to such $\langle w, G\rangle$ pairs as *possibilities*. And as a brief summary of the discussions given above, the generalization from world-assignment pairs to possibilities enables the dynamic system to have a fine-grained representation about the world and discourse information, especially concerning pluralities.

3.1.3 Context in Inq_D

The context in Dynamic Inquisitive Semantics (Inq_D) can be construed as an integration of the static inquisitive semantics Inq_B with the notion of *possibilities* generalized above. Let's try to make clear how exactly such integration can be realized through a step-by-step reasoning as follows:

(i) In the dynamic system PCDRT generalized from GSV, the basic semantic unit is upgraded from a possible world w to a possibility $\langle w, G\rangle$;

(i) The context in GSV or PCDRT is constructed in parallel with propositional meanings in corresponding static systems: the latter characterizes the semantics of a proposition with a set of possible worlds, and (thus) the former takes the context to be a set of possibilities;

(ii) In Inq_B, the notion of meaning is *lifted* from a set of possible worlds to a downward-closed set of information states, where an information state is characterized as a set of possible worlds;

Therefore, the integration goes as follows. The context in Inq_D is constructed in parallel with propositional meanings in its static counterpart Inq_B, namely, as a downward-closed set of sets of *possibilities*. In the rest of the thesis, we will give the name of an *information state* to a set of possibilities, and refer to a set of worlds simply as a *state*. As an interim summary, we list the definitions given so far for convenience.

3.2 Context Update: A Compositional Fragment of Inq_D

This section provides a basic formalization of Dynamic Inquisitive Semantics, including a type-theoretic frame of Inq_D and a formal definition of context (along with several context operations) introduced in the previous section. Meanwhile, it develops a semantic theory that maps natural language expressions into objects in the type-theoretic frame, as well as a set of compositional rules from which the semantics of complex constructions, and eventually propositions, can be derived. The semantic theory will be supplied with notational conventions paired with their semantic interpretations. Note that although these conventions stay on the level of meta-language in this section, they can all be packed into a type-logical vocabulary of Inq_D. We refer to Dotlačil and Roelofsen (2019) for details in this respect (as well as many other linguistic applications of Inq_D).

3.2.1 Formal Definitions

First, we will introduce the type system and the frame that semantic evaluations of Inq_D will be based on. Explicit formal definitions of the notions discussed in the previous section will then be given here in the type-theoretic framework.

3.2.1.1 Types and Frames

First let's lay out the type system of $\mathsf{Inq_D}$ that we will operate on. Besides basic types from Ty2, namely the types of individuals e, worlds s and truth values t, a basic type of discourse referents r is also included here. In constructing complex types, besides functional types, i.e. types of a function that maps an object of one type to another, we also include relational types in the construction, i.e. for any two types σ and τ, their cartesian product $(\sigma \times \tau)$ is also a type, categorizing a relation between them. The relational type will typically be used in constructing context.

Definition 3.1. ($\mathsf{Inq_D}$ types)

(i) $\mathsf{Inq_D}$ has four basic types: t for truth-values, s for possible worlds, e for individuals, r for discourse referents;

(ii) The set of all $\mathsf{Inq_D}$ types Types is the smallest set containing the basic types, and such that for any two type $\sigma, \tau \in \mathsf{Types}$, there is also $\langle \sigma, \tau \rangle \in \mathsf{Types}$ (sometimes abbreviated as $(\sigma\tau)$) and $(\sigma \times \tau) \in \mathsf{Types}$.

The semantics of $\mathsf{Inq_D}$ expressions will always be evaluated on an $\mathsf{Inq_D}$ model, which in turn resides in an $\mathsf{Inq_D}$ frame.

Definition 3.2. ($\mathsf{Inq_D}$ Frames)

An $\mathsf{Inq_D}$ frame is a set (of domains) $\{D_\tau \mid \tau \in \mathsf{Types}\}$ such that:

(i) D_e, D_s, D_t, D_r are pairwise disjoint;

(ii) D_e is the set of all non-empty subsets of a given set of entities E, i.e. $D_e = \wp^+(E) := \wp(E)\backslash\emptyset$;

(iv) D_s is a non-empty set of possible worlds;

(v) $D_t = \{0, 1\}$;

(vi) For any $(\sigma\tau) \in \mathsf{Types}$, $D_{(\sigma\tau)}$ is the set of all functions from D_σ to D_τ;

(vii) For any $(\sigma \times \tau) \in \mathsf{Types}$, $D_{\sigma\times\tau}$ is the set of all pairs in $D_\sigma \times D_\tau$

An $\mathsf{Inq_D}$ model, then, can be defined as an $\mathsf{Inq_D}$ frame F paired with an Interpretation function I over constants of each type, and a variable assignment function θ over variables of each type. The semantic sentences then can be given in the same manner as first-order logic, which we will omit here for now.

Some remarks on Definition 3.2 (ii): note that an individual in $\mathsf{Inq_D}$ is now defined as a subset of the set of entities E. This upgrade enables us to define atomic individuals as singleton sets in D_e, and plural individuals as non-singleton ones. We can also define the sum ($\oplus$) operation and parthood ($\leq$) relation in set-theoretic terms. Namely, the sum of two individuals (atomic or plural) $d, d' \in D_e$ is their union, denoted as $d \oplus d'$; the sum of a set of individuals $I \subset D_e$ is defined similarly, $\oplus I := \bigcup I$. The parthood relation $\leq$ is defined in terms of subset relation, i.e. $d \leq d'$ if $d \subseteq d'$; and its proper counterpart $<$ as well, i.e. $d < d'$ if $d \subset d'$.

Note that discourse referents are stored in the domain D_r, therefore dref assignment functions, which map discourse referents to individuals, are elements of $D_{(re)}$. Since a dref assignment function only has *active* drefs in its domain, we allow it to be a partial function, and its domain will be denoted by $\delta \subseteq D_r$. Further, we define a dref assignment matrix as a set of dref assignment functions with the same domain δ.

Definition 3.3. (dref Assignment Functions and Matrices)

Let F be an $\mathsf{Inq_D}$ frame and $\delta \subseteq D_r$ a set of discourse referents in F.

(i) A dref assignment function is a **partial** function $g \in D_{(re)}$ with $\mathbf{dom}(g) := \delta \subseteq D_r$;

(ii) A dref assignment matrix is a non-empty set of dref assignment functions $G \in D_{(re)t}$ with a same domain δ; we abbreviate the type $(re)t$ as m.

Note that a dref assignment matrix is by definition non-empty, and if no drefs have been introduced yet, we assume that the dref assignment matrix is $\{\emptyset\}$, i.e. a singleton set containing an empty function. This stipulation will benefit subsequent definitions regarding context extension.

With everything at hand, we can now regenerate the step-by-step introduction of $\mathsf{Inq_D}$ context in §3.1 with formal definitions.

Definition 3.4. (Possibilities)

For any set of discourse referents δ, a *possibility* with domain δ is a pair $\langle w, G\rangle \in D_{s\times m}$ where w is a possible world and G a dref assignment matrix with domain δ.

Definition 3.5. (Information States)

An *information state* is a set of possibilities, thus of type $((s \times m)t)$, abbreviated as i.

Definition 3.6. (Contexts)

(i) Downward closure: a set S of information states is *downward closed* iff for every $s \in S$, every subset of s is also in S.

(ii) A *context* is a non-empty, downward closed set of information states, thus of type (it), abbr. k.

Let's end this series of definitions of the *domain* of information states and context, as it corresponds directly to the set of active drefs, thus is important for discussions below regarding context update.

Definition 3.7. (The Domain of an Information State and a Context)

(i) The *domain* of an information state s is the union of the domains of the possibilities in s.

(ii) The *domain* of a context c is the union of the domains of the information states in c.

To summarize, we list the types and their abbreviations corresponding to the notions defined above in the following Table 3.1.

3.2.2 Context Update: A Preview

As we discussed above, propositional meanings are modeled as context update functions in dynamic systems. As pointed out by Dotlačil and Roelofsen (2019), context updates in non-inquisitive systems such as GSV and PCDRT can be divided into two classes: (a) *constructive* updates that introduce new discourse referents and create new possibilities, and (b) *eliminative* updates which remove possibilities. In an inquisitive setting such as $\mathsf{Inq_D}$, the notion of *eliminative* updates need to be revised. First, instead of possibilities,

Object	Type	Abbreviation
dref assignment function	(re)	-
dref assignment matrix	$((re)t)$	m
Possibility	$(s \times m)$	-
information state	$((s \times m)t)$	i
context	(it)	k

Table 3.1: Types and Abbreviation Conventions

such updates eliminate *information states* (while preserving the downward-closure); second, by eliminating information states, an update function doesn't necessarily provide new information - it may also raise *issues* by carving out the alternatives that resolve it. In this section, we take a macro perspective on update functions, namely, we look at how context can be changed given an arbitrary proposition, without inspecting the inner structure of the proposition. A compositional fragment will be provided in the next section.

3.2.2.1 Informative and Inquisitive Context

Let's first lay out some basic notions regarding the (inquisitive) properties of a context c. The major properties of update functions, as we will see later, can then be characterized as their potential to change the properties of a context. The content of this part is simply an extension of the static $\mathsf{Inq_B}$ to its dynamic counterpart, and all the notions defined here can be traced back to the ones defined in §2.2.1.1. Therefore we will simply display the formal notions with minimal explanations.

Definition 3.8. (Informative Content)
For any context c, its *Informative Content* $\mathsf{info}(c) := \bigcup c$.

Definition 3.9. (Informativeness)
A context c with domain δ is *Informative* iff there is a possibility $\langle w, G \rangle$ with domain δ such that $\langle w, G \rangle \notin \mathsf{info}(c)$. Otherwise, c is *Uninformative*.

With the requirement of downward-closure, a context c, just like an inquisitive proposition, can be represented by means of its *maximal elements*, i.e. the *alternatives*. The $\mathsf{Inq_D}$ version of alternatives is defined as follows.

Definition 3.10. (Alternatives)
The set of *Alternatives* of a context c, $\mathsf{alt}(c) := \{s \in c \mid \text{there is no } t \in c \text{ such that } t \supset s\}$.

With the notion of alternatives, we can further define the *inquisitiveness* of a context.

Definition 3.11. (Inquisitiveness)
A context c is *Inquisitive* iff $|\mathsf{alt}(c)| > 1$, or equivalently, $\mathsf{info}(c) \notin c$.[19]

Finally, we define the notion of trivial contexts, the initial context and inconsistent context as follows.

[19]The equivalence, however, only holds when the set of possibilities is finite, which we will assume to be the case here.

Definition 3.12. (Trivial Contexts)

A context c is *trivial* iff it is neither informative nor inquisitive.

Definition 3.13. (The Initial Context $c_\top$)

The *initial context* $c_\top$ is the trivial context whose domain is empty.

Definition 3.14. (The Inconsistent Context $c_\bot$)

The inconsistent context $c_\bot := \{\emptyset\}$.

3.2.2.2 *Constructive* Update: Context Extension and Subsistence

As mentioned above, context updates can function in a *constructive* way and an *eliminative* way. In static settings, on the other hand, dref information is left out, so context updates are usually reduced to the *eliminative* cases only. Whereas in dynamic settings, context updates also refer to cases where context is extended with new drefs that are further encoded into the *domain* of the context. In this section, the definition of *extensions* will be spelled out, along with a special case called *subsistence* (following Groenendijk et al., 1995). Note that the notion of *extensions* is compatible with eliminative operations (in fact it even rejects the introduction of contradictory information), but we believe it can be better understood in terms of domain extensions w.r.t. drefs. As a suitable illustration, therefore, we will introduce the very first update function in $\mathsf{Inq_D}$, namely $[u]$, that stands for the introduction of a dref u.

In principle, an *extension* of a context c should satisfy the following two conditions: (i) it maintains the world information established by c, and possibly add compatible pieces; and (ii) it maintains the discourse information established by c, and possibly add new ones. The second condition, in particular, is crucial for us to understand *extensions* in a dynamic system. Therefore, here we first specify what it means to extend a dref assignment function/matrix:

Definition 3.15. (Extending dref Assignment Functions and Matrices)

(i) A dref assignment function g' is an *Extension* of another dref assignment function g, written as $g' \geq g$, iff $\mathbf{dom}(g') \supseteq \mathbf{dom}(g)$, and for all $u' \in \mathbf{dom}(g)\backslash\{u\}$, $g(u) = g'(u)$.

(ii) A dref assignment matrix G' is an *Extension* of another dref assignment function G, written as $G' \geq G$, iff for every $g' \in G'$, there is $g \in G$ such that $g' \geq g$ and for every $g \in G$, there is $g' \in G'$ such that $g' \geq g$.

That is, an extension of a dref assignment function/matrix does not *destroy* discourse information that is already established, only creates new ones. Based on this notion, we can further define the extensions of possibilities, information states, and finally contexts.

Definition 3.16. (Extending Possibilities)

A possibility $\langle w', G' \rangle$ is an *Extension* of another possibility $\langle w, G \rangle$, written as $\langle w', G' \rangle \geq \langle w, G \rangle$, iff $w = w'$ and $G' \geq G$.

Definition 3.17. (Extending Information States)

An information state s' is an *Extension* of another information state s, written as $s' \geq s$, iff for every possibility $\langle w', G' \rangle \in s'$, there is $\langle w, G \rangle \in s$ such that $\langle w', G' \rangle \geq \langle w, G \rangle$.

Definition 3.18. (Extending Contexts)

A context c' is an *Extension* of another context c, written as $c' \geq c$, iff for every information state $s' \in c$, there is $s \in c$ such that $s' \geq s$.

Note that the Definition 3.17, 3.18 of extensions of information states and contexts differ in form from Definition 3.15 in that 3.17, 3.18 only require each member of the extended set to have a counterpart in the original set, but 3.15 requires each element in the original set to be extended as well. The difference corresponds directly to the fact that world information in the context can be *eliminated*. However, it is useful to also define a specific kind of context extension that only involves the addition of discourse information. Following Groenendijk et al. (1995), such extension is called *subsistence*.

Definition 3.19. (Subsistence of one Information States in another)

An information state s *subsists* in another information state s', written as $s \preccurlyeq s'$, iff $s' \geq s$ and for every possibility $\langle w, G\rangle \in s$, there is $\langle w', G'\rangle \in s'$ such that $\langle w', G'\rangle \in s' \geq \langle w, G\rangle$.

Definition 3.20. (Subsistence of an Information State in a Context)

An information state s *subsists* in a context c, written as $s \preccurlyeq c$, iff there is one or more $s' \in c$ such that $s \preccurlyeq s'$. Such s' is called a *descendant* of s in c.

Definition 3.21. (Subsistence of a Context in another)

A context c *subsists* in another context c', written as $c \preccurlyeq c'$, iff $c' \geq c$ and for every $s \in c, s \preccurlyeq c'$.

The subsistence of a context c in another one c' can also be phrased as *c support c'*. Now, let's get a bit more specific and introduce the first update function in $\mathsf{Inq_D}$—the function $[u]$—that introduces a dref indexed by u. $[u]$ is a context update function, thus of type (kk); and it can informally described as taking a context c as input, and output a context c' such that $c \preccurlyeq c'$ (no world information destroyed) and c' is enriched from c with a new dref u. To formally define it, we make use of the following sentences from the logical vocabulary:

(78) a. $g[u]g' := [\mathbf{dom}(g') = \mathbf{dom}(g) \cup \{u\}] \wedge \forall v \in \mathbf{dom}(g) \cap \mathbf{dom}(g') : g(v) = g(v')$
where g, g' are dref assignment functions of type (re).

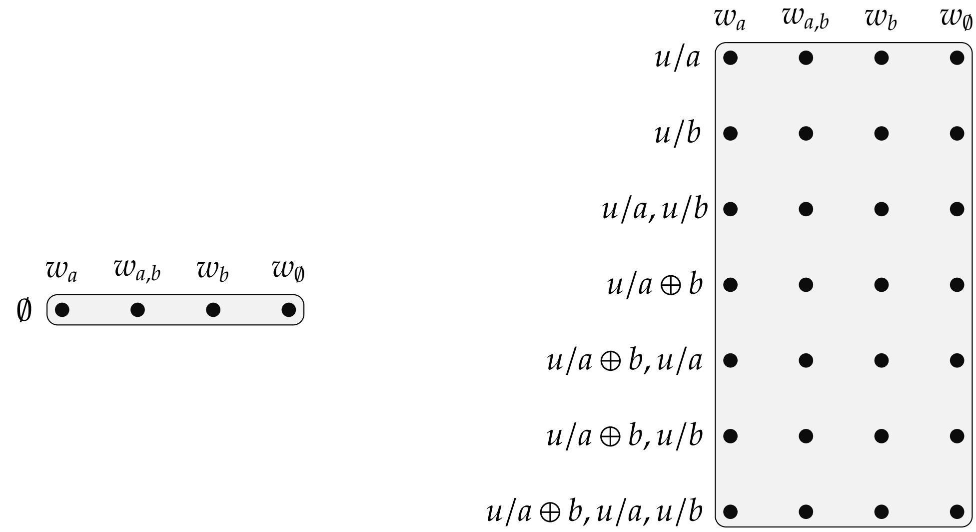
b. $G[u]G' := \forall g \in G : \exists g' \in G'. g[u]g' \wedge$
$\forall g' \in G' : \exists g \in G. g[u]g'$
where G, G' are dref assignment matrices of type m.

c. $p[u]p' := \pi_1(p) = \pi_1(p') \wedge \pi_2(p)[u]\pi_2(p')$, where
- p, p' are possibilities of type $(s \times m)$;
- π_1, π_2 are projection function such that for any possibility $p = \langle w, G\rangle$, $\pi_1(p) = w, \pi_2(p) = G$. In the following, we will also write $\pi_1(p)$ as w_p, $\pi_2(p)$ as G_p.

The logical expressions given in (78) instantiate the informal description of the introduction of u on different levels - from dref assignment function in (78a), to dref matrix in (78b), and to possibility in (78c). Based on these notions, the semantic entry of $[u]$ is given as follows:

(79) $[u] := \lambda c_k \lambda s'_i. \exists s \in c. [\forall p' \in s' : \exists p \in s. p[u]p'] \wedge [\forall p \in s : \exists p' \in s'. p[u]p']$

As we can see, the condition corresponds to the definition of *subsistence* directly, and in addition, the extension is achieved through the introduction of u. Let's illustrate with an example. Consider an input context c with only two entites a, b, and an empty domain, as shown in Fig. (3.1a). An application of $[u]$ on c then yields a new context that is extended from c with arbitrary sets of values for u, as shown in Fig. (3.1b). In the current and the rest of the diagrams, each black dot will represent a possibility. The world component is specified above it and fixed for each column, and the dref matrix is specified to its left and fixed for each row. The context will be represented by dashed rectangles enclosing its alternatives. Here the difference between $w_a, w_b, w_{a,b}$ and $w_\emptyset$ is neither specified nor made use of, but it will have effect when we introduce *eliminative* updates.



(a) (b)

Figure 3.1: Application of the dref introduction operator $[u]$

3.2.2.3 *Eliminative* Update: Issues and Information

The last section explained how contexts can be updated/extended *constructively* via introductions of discourse information. In this section, we turn to the more familiar kind of context updates, namely *eliminative* updates. Meanwhile, as mentioned above, the notion of *eliminative* updates has been enriched in the inquisitive setting, as such update may both provide information and raise issues. Below, we will provide formal notions that characterize the informativeness and inquisitiveness of an update function. Moreover, two special relations that hold between a context and an update functions, namely *support* and *consistency*, and a relation between update functions, namely *entailment*, will be provided. As promised, we will stay on a macro perspective and only reason about an arbitrary update function A of type (kk). The various instantiations of update functions with different properties will be discussed in the next section, with natural language counterparts. In the following, we denote the context resulting from applying A to an input context c as $A(c)$.

An update function may not be well-defined for every context c, that is, it may be a partial function. In particular, if an update function A refers to a dref u that is not in the domain (see Definition 3.7) a context c, then $A(c)$ will be undefined. Now let's proceed to the definitions of inquisitiveness and informativeness of an update function.

Definition 3.22. (Informative and Inquisitive Update Functions)

- An update function A is *informative* iff there exists an uninformative context c such that $A(c)$ is defined and informative.
- An update function A is *inquisitive* iff there exists a non-inquisitive context c such that $A(c)$ is defined and inquisitive.

Meanwhile, an update function can be contradictory or tautologic:

Definition 3.23. (Contradictions and Tautologies)

- An update function A is a *Contradiction* iff for any context c, $A(c) = c_\bot$.
- An update function A is a *Tautology* iff for any context c, $A(c) = c$.

We mentioned in the previous chapter that the notion of *subsistence* between contexts, say $c \preccurlyeq c'$, can be rephrased as *c supports c'*. Here, we use the notion of subsistence to define the support relation between a context and an update function:

Definition 3.24. (Support)
A context c *supports* an update function A iff $A(c)$ is defined and $c \preccurlyeq A(c)$.

Even if a context doesn't support an update function, they can still be consistent:

Definition 3.25. (Consistency)
An update function A is *consistent* with a context c iff $A(c)$ is defined and $A(c) \neq c_\bot$.

Finally, we define the entailment relation for update functions. The notion of entailment in Dotlačil and Roelofsen (2019) follows the "update-to-test" notion of entailment, following Groenendijk et al. (1995):

Definition 3.26. (Entailment)
Let $A_1, ..., A_n$ and B be update functions. Then $A_1, ..., A_n$ *entail* B, written as $A_1, ..., A_n \vDash B$, iff for every context c such that $A_n(...A_1(c))$ is defined, $A_n(...A_1(c))$ supports B.

3.2.3 Context Update: Compositional $\mathsf{Inq_D}$

Now let's move from the previous macro perspective to a micro one. This section provides an extensive introduction on how update functions with different properties can be composed. Various logical expressions will be introduced with semantic interpretations. Moreover, for the purpose of the thesis, natural language counterparts will be provided as illustrations, and given semantic characterizations in the framework of $\mathsf{Inq_D}$.

3.2.3.1 Atomic Propositions and Conjunction

We start with the basic *eliminative* context update, namely atomic propositions. On a first-order setting (as is the case for $\mathsf{Inq_D}$), an atomic proposition is composed by applying an n-ary relation R of type $(e^n(st))$ on an n-tuple of individuals of type e, say $d_1, ..., d_n$[20]. The basic logic expression has the following semantic characterization:

(80) Given an $\mathsf{Inq_D}$ frame F, and Interpretation function I: $R(d_1, ..., d_n)(w) = 1$ iff $\langle I(d_1), ..., I(d_n)\rangle \in I(R)$ at w.

Meanwhile, following the tradition of Link (1983), Krifka (1989), Landman (2012) and others, we define the *pluralization* of a relation R, written as ${}^*R$, as a *cumulative closure*:

(81) For all $d_1, ..., d_n, d'_1, ..., d'_n \in D_e$ and all $w \in D_s$:
- If $R(d_1, ..., d_n)(w) = 1$, then ${}^*R(d_1, ..., d_n)(w) = 1$;
- If $R(d_1, ..., d_n)(w) = 1$ and $R(d'_1, ..., d'_n)(w) = 1$, then $R(d_1 \oplus d'_1, ..., d_n \oplus d'_n)(w) = 1$.

In a dynamic setting like $\mathsf{Inq_D}$, individuals are usually retrieved via applying a dref assignment function g on a dref u. Therefore, as a variation of atomic propositions, we let $R\{u_1, ..., u_n\}$ denote an update function as well. The semantic interpretation is given as follows:

(82) $R\{u_1, ..., u_n\} := \lambda c_k \lambda s_i.\, s \in c \wedge \forall p \in s : \forall g \in G_p({}^*R(w_p)(g(u_1), ..., g(u_n)))$

Recall that G_p denotes the dref-matrix component of the possibility p, i.e. for $p = \langle w, G\rangle$, $w_p = \pi_1(p) = w, G_p = \pi_2(p) = G$. The update function defined in (82) thus keeps only those states s in the input context c such that for every possibility $p \in s$ and every assignment $g \in G_p$, the n-tuple $g(u_1), ..., g(u_n)$ is in the extension of ${}^*R$ at w_p. Note that the evaluation is done 'distributively' over each dref assignment functions, thus (82) can be used to formally interpret nominal predicate such as '*avocado*', or verbal distributive predicates such as '*come*':

(83) a. $[\![\text{avocados}]\!] = \lambda v_r.\, \mathbf{avocado}\{v\}$
b. $[\![\text{come}]\!] = \lambda v_r.\, \mathbf{come}\{v\}$

On the other hand, we can define a different update function that corresponds to a 'collective' evaluation of a relation over a set of drefs:

(84) $R\{u_1^{\oplus}, ..., u_n^{\oplus}\} := \lambda c_k \lambda s_i.\, s \in c \wedge \forall p \in s :\ {}^*R(w_p)(\oplus G(u_1), ..., \oplus G(u_n)),$
where $\oplus G(u_i) := \oplus\{g(u_i) \mid \text{for some } g \in G\}$

(84) can be used to formalize collective predicates, such as '*gather*':

(85) $[\![\text{gather}]\!] = \lambda v_r.\, \mathbf{gather}\{\oplus v\}$

Let's illustrate corresponding update functions with the following diagrams. Recall that Fig. Fig. (3.1b) depicts a context c after the introduction of the dref u. First consider the distributive predicate *come*. Assuming the subscripts of the world components represent the individual who comes (e.g. w_a is the world where only a comes, and $w_{a,b}$ the one where both a and b come), then an update via the function **come**$\{u\}$ yields the output context as in 3.2.

[20] We use $(e^n(st))$ as an abbreviation of the type of functions that take n individuals as input and yield a truth value as output.

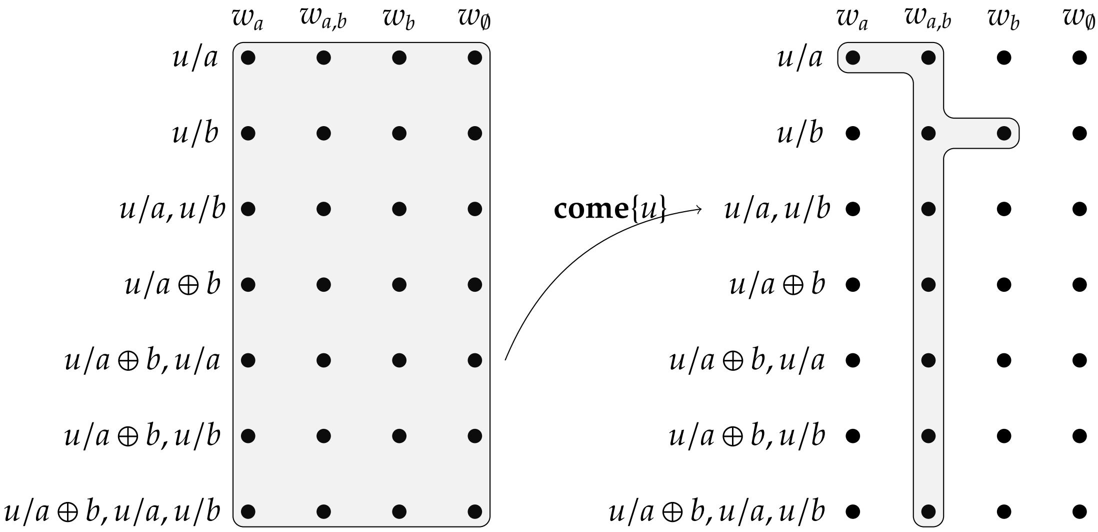


Figure 3.2: Update effect of the atomic proposition **come**$\{u\}$

It is also possible for a relation to operate on collective values of some arguments and distributive values of another. Such mixed case is captured as follows:

(86) $R\{u_1, ..., u_n, u^{\oplus}_{n+1}, ..., u^{\oplus}_m\} := \lambda c_k \lambda s_i.\, s \in c \wedge \forall p \in s :$
$$\forall g \in G_p({}^*R(w_p)(g(u_1))...g(u_n)(\oplus G_p(u_{n+1}))...(\oplus G_p(u_m)))$$

We will use the definitions (82) and (84) above to distinguish between *assignment-level* predicates and *possibility-level* predicates. Meanwhile, as pointed out by Dotlačil and Roelofsen (2019), collective and distributive predicates do not correspond to possibility-level and assignment-level predicates without exception. Though it is assumed that all possibility-level predicates are collective, collective predicates such as '*be numerous, elected the president*' seems to receive an assignment-level interpretation:

(87) $[\![\text{numerous}]\!] = \lambda v_r.\, \textbf{numerous}\{v\}$

A motivation for separating collective assignment-level predicates such as '*numerous*', is its different behavior, compared to possibility-level predicates, when associating with universal quantifiers like '*every*' and '*all*', as exemplified as follows:

(88) a. *Every boy gathered./All the boys gathered.
b. *Every boy elected the president./*All the boys elected the president.

Thus, Dotlačil and Roelofsen (2019) provide a test to identify possibility-level and assignment-level predicates following Winter (2002):

(89) a. If a predicate P (under some reading) has the same acceptability status when it combines with *every* and when it combines with *all*, it is assignment-level (under the reading).
b. If a predicate P (under some reading) has a different acceptability status when it combines with *every* than when it combines with *all*, it is possibility-level (under that reading).

A semantic explanation of the pattern as in (88) will be given when the translations of different types of quantifiers are introduced in §3.2.3.3.

We will end this section by introducing the conjunction between update functions. As a custom in dynamic semantics, the conjunction will be represented as a *merging* operation denoted by ;, which signals a two-step update on the context by the first and the second conjunct sequentially.

(90) $A_{(kk)}; B_{(kk)} := \lambda c_k. B(A(c))$

3.2.3.2 Raising Issues

In this section, we specify ways of raising issues. An issue can be raised through disjunction (e.g. alternative questions), via the ? operator (e.g. polar questions), and by raising *identity questions* w.r.t. a dref u, written as $?u$. The last one, as we will see, is introduced into the semantics of *wh*-questions.

The update effect of a disjunction is obtained by taking the union of the result of separately updating the input context with each disjunct, as follows:

(91) $A_{(kk)} \sqcup B_{(kk)} := \lambda c_k. A(c) \cup B(c)$

As is the case in $\mathsf{Inq_B}$, represented as the union of two contexts, a disjunction can give rise to an inquisitive output. Disjunction can be used to model alternative questions, as follows:

(92) $[\![$Did John$_{u_1}$ come or Bill$_{u_2}$?$]\!] = \lambda c_{(kk)}. [\mathbf{come}\{u_1\} \sqcup \mathbf{come}\{u_2\}](c)$

Meanwhile, the inquisitiveness of a disjunction can be *discharged* via the projection operator !, which is defined similarly in $\mathsf{Inq_D}$ as in $\mathsf{Inq_B}$:

(93) a. For any context c, $!c := \{\mathsf{info}(c)\}^{\downarrow} = \{s \mid s \subseteq \mathsf{info}(c)\}$;
b. For any update function A, $!A_{(kk)} := \lambda c_k \lambda s_i. s \in !A(c) \wedge \exists s' \in c. s \geq s'$

The extra condition in (93b) ensures that information states in the new context still resolve the issues that were present in the old context c, as A might be a non-informative update function operating on an inquisitive context c.[21] Declarative disjunctions can thus be modeled as a disjunction with issues discharged by !, as exemplified in (94):

(94) $[\![$John$_{u_1}$ or Bill$_{u_2}$ come$]\!] = \lambda c_k. [!(\mathbf{come}\{u_1\} \sqcup \mathbf{come}\{u_2\})](c)$

The update effects are illustrated as follows. While the disjunction creates an inquisitive context, ! discharges such inquisitiveness.

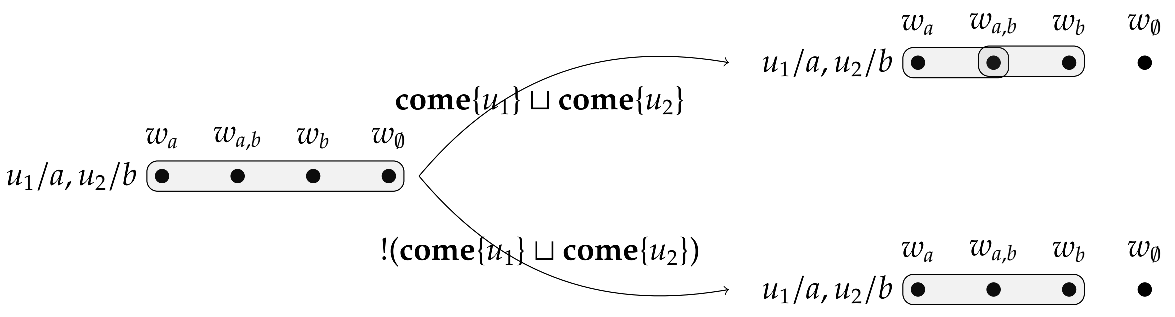


Figure 3.3: Update effects of inquisitive and non-inquisitive disjunctions

Another way of raising issue is via the ? operator. In $\mathsf{Inq_B}$, a proposition $?\varphi$ is defined as the disjunction of φ and its negation. In $\mathsf{Inq_D}$, the operator can be defined similarly:

[21] As discussed in (Dotlačil and Roelofsen, 2019, p. 30), it also ensures the projection of discourse referents, thus is able to capture declarative disjunctions as 'externally dynamic' (Groenendijk and Stokhof, 1991; Groenendijk et al., 1995).

(95) a. $\neg A_{(kk)} := \lambda c_k \lambda s_i. s \in c \wedge \forall t \subseteq s : [t \neq \emptyset \rightarrow t \not\preccurlyeq A(c)]$

b. $?A_{(kk)} := A \sqcup \neg A$

To understand (95a), recall that the notion of subsistence $\preccurlyeq$ can be rephrased as a *support* relation. Then the condition in (95a) can be read as for any information state s in the output context, the update of the orginal context c by A doesn't support any of its subsets. Therefore s contradicts the information in $A(c)$, thus the negation. The ? operator can be used to model polar questions:

(96) $[\![\text{Did John}_u \text{ come?}]\!] = ?\mathbf{come}\{u\}$

Finally, Inq_D introduces an *identification operator* **?***u* which is used to raise an issue about the identity of the dref u. The definition of **?***u* is as follows:

(97) $\mathbf{?}u := \lambda c_k \lambda s_i. s \in c \wedge \exists x_e. \forall p \in s : \forall g \in G_p(x = g(u))$

That is, **?***u* reduces the input context c to a new one where the possibilities in each state are such that the members of their dref matrices agree on the individual assigned to u. The operator **?***u* is used to derive the semantic interpretations of (single) *wh*-questions, as exemplified in (98):

(98) $[\![\text{Who}^u \text{ came?}]\!] = [u]; \mathbf{come}\{u\}; \mathbf{?}u$

Therefore a (single) *wh*-question can be interpreted as a merge of three update functions - first, the *wh*-phrase introduces a dref u; second, the predicate fixes the conditions u has to satisfy; and third, ask about the identity of u. The result of the update is illustrated in the following diagram.

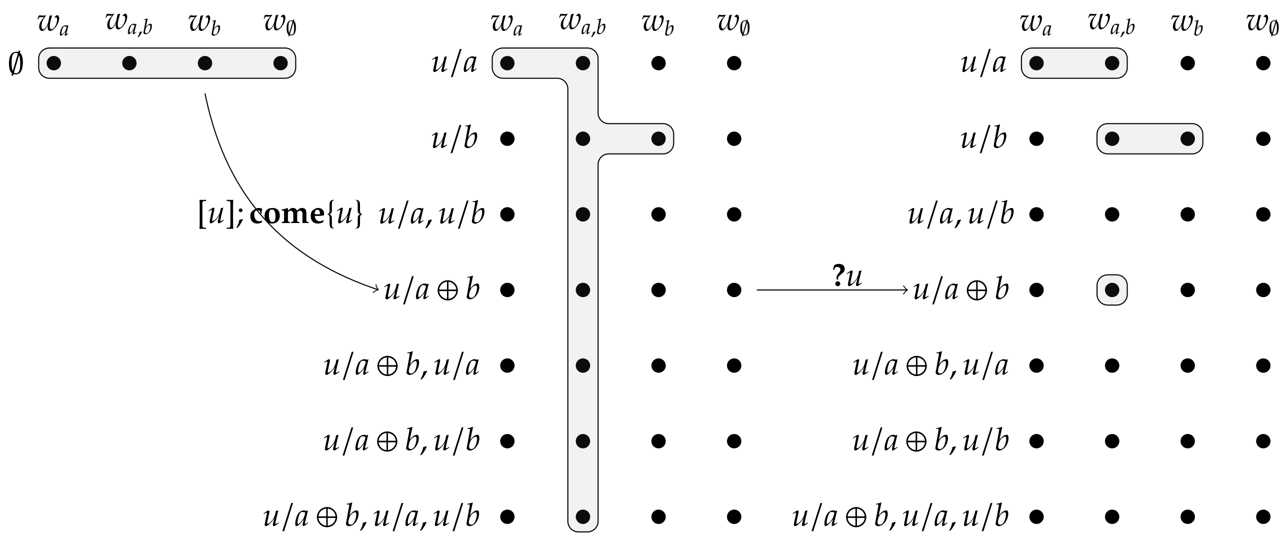


Figure 3.4: Update effect of the single *wh*-question '*Who came*?'

3.2.3.3 Quantifications

Quantifiers are commonly treated as coordinations between predicates in formal semantics (Barwise and Cooper, 1981). In dynamic semantics, however, as quantifiers sometimes introduce drefs (e.g. *some*, *a*, *every*), they will also interact with/coordinate the discourse information stored in relevant drefs. Therefore, before proceeding to the treatment of quantifiers, we present two special operators over drefs, **atom** and **max**, that are used to restrict their assignment functions.

As mentioned above the PCDRT section §3.1.2, singularity/plurality information of a nominal phrase can be provided by its lexical or morphological constructions. The operator **atom** addresses these information. When operating on a dref u, it restricts the values that are assigned to u to be atomic. The atomicity can manifests on different levels (assignment level, possibility level and state level), and they are defined as follows:

(99) a. $\textbf{atom}_{\text{assign}}\{u\} := \lambda c_k \lambda s_i.\, s \in c \wedge \forall p \in s : \forall g \in G_p.(\neg \exists y.y < g(u))$
b. $\textbf{atom}_{\text{poss}}\{u\} := \lambda c_k \lambda s_i.\, \forall p \in s :\ \neg \exists y.y < \oplus G_p(u)$
c. $\textbf{atom}_{\text{state}}\{u\} := \lambda c_k \lambda s_i.\, s \in c \wedge \neg \exists y(y < \oplus\{g(u) \mid \exists p \in s.\, g \in G_p\})$

As is hinted by the subscript, **atom** imposes atomicity requirement on different levels of assignments w.r.t. the associated dref. We illustrate its update effect in Fig. (3.5). As is shown in the diagram, the update eliminates assignment matrices that violate the atomicity requirement.

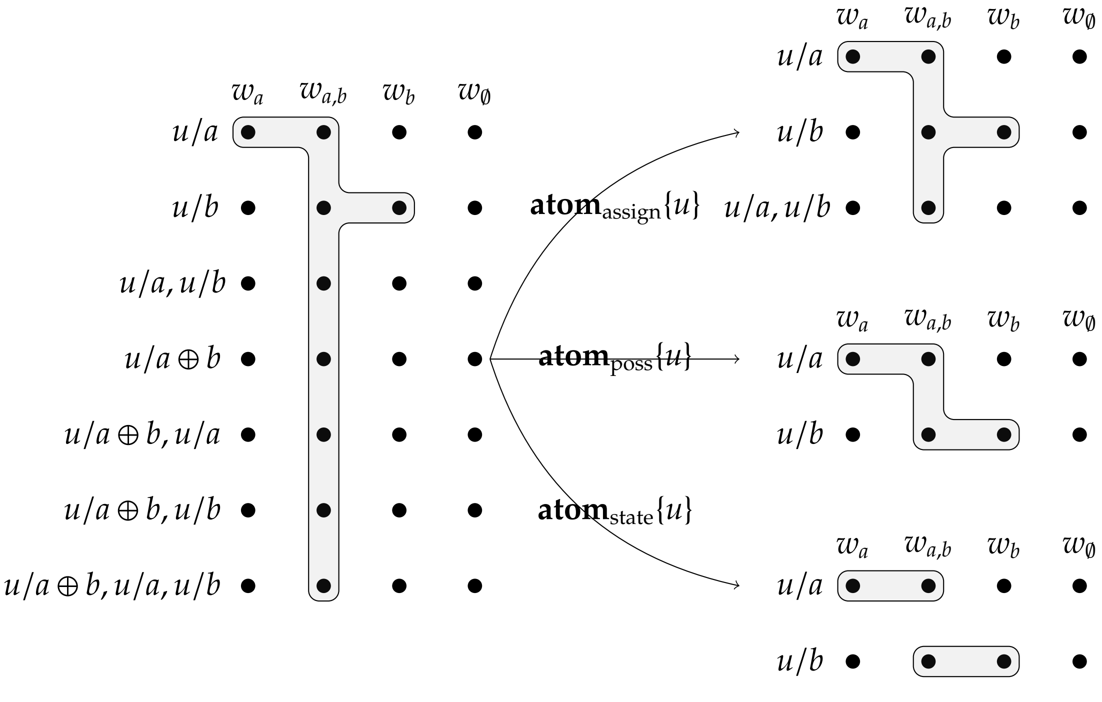


Figure 3.5: Update effects of $\textbf{atom}\{u\}$

As mentioned above, nominal predicate with singular morphology enforces domain-level singularity. We can model such requirement with the help of $\textbf{atom}_{\text{assign}}$:

(100) a. $[\![\text{avocados}]\!] = \lambda v_r.\, \textbf{avocado}\{v\}$
b. $[\![\text{avocado}]\!] = \lambda v_r.\, \textbf{atom}_{\text{assign}}\{v\}; \textbf{avocado}\{v\}$

The operator **max**, when combined with a dref u, enforces its assignment to be *maximal*:

(101) $\textbf{max}\{u\} := \lambda c_k \lambda s_i.\, s \in c \wedge \forall p \in s.\, \forall p' \in \bigcup c.\, (w_p = w_{p'} \to G_{p'}(u) \subseteq G_p(u))$

That is, **max** takes a dref u as argument, and yield an update function such that that given any input context c, the output keeps only those information states whose possibilities

p assign a maximal entity to u (in terms of the sum $\oplus G_p(u)$). It will be used in the characterization of (distributive) universal quantifiers such as *every/each*, and Brasoveanu (2008) implemented it to capture strong and weak donkey anaphora[22].

Now let's turn to the translations of quantifiers. Dotlačil and Roelofsen (2019) (following Beghelli, 1997; Szabolcsi, 1997, and others) distinguishes between three types of quantifiers: distributive quantifiers (e.g. *every*, *each*), counting quantifiers (e.g. *most*, *all* and modified numerals) and indefinites (e.g. *some*, *a*). Since quantifiers are usually of types higher than (one-place) predicates (type $r(kk)$), we will make the following abbreviation for convenience.

	Type	Abbreviation
Update function	(kk)	$\mathbf{T}$
Unary predicate	$r(kk)$	$r\mathbf{T}$
Quantifier	$r(kk)(kk)$	$r\mathbf{TT}$

Table 3.2: More Type Abbreviations

Let's start with **indefinites**. They are interpreted as an introduction of a dref that satisfies the predicates given in the restrictor and nuclear scope.

(102) $[\![\text{some/a}^u]\!] = \lambda P_{r\mathbf{T}} \lambda P'_{r\mathbf{T}}.\, [u]; P\{u\}; P'\{u\}$

As their anaphoric counterparts, pronouns can also be interpreted similarly, except that instead of introducing a dref, they refer back to an active one. The number features also provide additional atomicity/plurality requirements.

(103) a. $[\![\text{they}_u]\!] = \lambda P.\, P(u)$
b. $[\![\text{he/she/him/her/it}_u]\!] = \lambda P_{r\mathbf{T}}.\mathbf{atom}_{\text{assign}}\{u\}; P(u)$

Counting quantifiers such as *most*, *all* and modified numerals are often modeled as establishing a set-theoretic/cardinality relation between the extensions of the restrictor and nuclear scope predicates in the theory of generalized quantifiers. Denoting an arbitrary counting quantifier as **det** with a static counterpart DET, a general formalization of its semantics can be given as follows:

(104) $[\![\mathbf{det}^u]\!] = \lambda P_{r\mathbf{T}} \lambda P'_{r\mathbf{T}} \lambda c_k \lambda s_i.\, s \in c \wedge \forall p \in s : \textsc{det}(u_p[P, c], u_p[P, P', c])$, where

- $u_p[P, c] := \bigcup\{G_{p'}(u) \,|\, p \preccurlyeq p' \wedge p' \in ([u]; \mathbf{atom}_{\text{assign}}\{u\}; P(u))(c)\}$
- $u_p[P, P', c] := \bigcup\{G_{p'}(u) \,|\, p \preccurlyeq p' \wedge p' \in ([u]; \mathbf{atom}_{\text{assign}}\{u\}; P(u); P'(u))(c)\}$

In particular, the supplementary notation $u_p[P, c]$ ($u_p[P, P', c]$) pick out all the atomic individuals that satisfy the predicates P (both P and P') so that the set-theoretic relation introduced by DET can be applied. As an example, the semantics of *all* can be given as follows:

(105) $[\![\text{all}^u]\!] = \lambda P_{r\mathbf{T}} \lambda P'_{r\mathbf{T}} \lambda c_k \lambda s_k.\, s \in c \wedge \forall p \in s : u_p[P, c] \subseteq u_p[P, P', c]$

The last type of quantifiers is the **distributive quantifiers** such as *every*, *each*. In a nutshell, they differ with indefinites and counting quantifiers in that they require *distributive* evaluations of the nuclear scope predicates over the restrictors. This requirement is encoded into a distributive operator δ_u defined as follows:

[22] We will not further address this issue in the thesis. However, see Champollion et al. (2017a) for an alternative approach

(106) $\delta_u := \lambda A_{kk}\lambda c_k\lambda s_i.\, s \in c \wedge \forall t \subseteq s \forall x_e : \; t_{u=x} \preccurlyeq A(\{t_{u=x}\})$, where

- $t_{u=x} := \{\langle w_p, G_{p,u=x}\rangle \,|\, p \in t \text{ and } G_{p,u=x} \neq \emptyset\}$
- $G_{p,u=x} := \{g \,|\, g \in G_p \text{ and } g(u) = x\}$

Let's unpack the definition from bottom up. First, for each possibility p, $G_{p,u=x}$ picks out the element $g \in G_p$ that assigns x to u. For an arbitrary $x \in D_e$, $G_{p,u=x}$ might be empty, but each non-empty $G_{p,u=x}$ has an agreement on the assignment of u among its elements. Then, for any information state t, $t_{u=x}$ is constructed by singling out the possibilities $p \in t$ such that $G_p = G_{p,u=x}$. This construction separates all possible assignments of u in t. Finally, the distributive operator δ_u takes an update function A and tests it over a state s. If for all $x \in D_e$ and all $t \subseteq s$, its component $t_{u=x}$ separated by x supports $A(t_{u=x})$ (if $t_{u=x} = \emptyset$, it vacuously supports $A(t_{u=x})$ as well), then s is claimed to pass the test. Therefore, δ provides a apparatus through which functions can be evaluated distributively w.r.t. possible individuals.

Finally, the semantic interpretations of distributive quantifiers is given in (107), with the help of δ:

(107) $[\![\text{every/each}^u]\!] = \lambda P_{r\mathbf{T}}\lambda P'_{r\mathbf{T}}.\, [u]; P(u); \mathbf{max}\{u\}; \delta_u(P'(u))$

Note that the operator **max** is also used here due to the universal force of *every*[23].

We will end this section by showing how the above definitions can be implemented to account for the puzzle of assignment-level collective predicates, as exemplified in (88). First, given the semantics of *every* in (107), the 'every' sentences in (88) can be translated as follows:

(108) a. $[\![\text{Every}^u \text{ boy gathered}]\!] = [u]; \mathbf{atom}_{\text{assign}}\{u\}; \mathbf{boy}\{u\}; \mathbf{max}\{u\}; \delta_u(\mathbf{gather}\{u^{\oplus}\})$

b. $[\![\text{Every}^u \text{ boy elected the president}]\!]$
$= [u]; \mathbf{atom}_{\text{assign}}\{u\}; \mathbf{boy}\{u\}; \mathbf{max}\{u\}; \delta_u(\mathbf{elect\text{-}the\text{-}president}\{u\})$

In (108a), the update function is constructed as follows. '*Every*' introduces a dref u; due to the singular morphology of '*boy*', assignment-level atomicity is required for the assignment functions of u; meanwhile, since '*every*' is a distributive quantifier, δ_u is applied to evaluate each possible assignment. However, due to the assignment-level atomicity, the evaluation w.r.t. **gather** will be imposed on atomic individuals, which results in inconsistency if we assume *gather* to be a collective predicate that only admits plural arguments. The same reasoning can be applied in (108b) towards the same conclusion. Thus the infelicity of the '*every*' sentences in (88) is explained.

Now let's consider the '*all*' sentences. Based on the semantics of *all* given in (105), we have the following translations:

(109) a. $[\![\text{All}^u \text{ boys gathered}]\!] = \lambda c_k\lambda s_i.\, s \in c \wedge \forall p \in s : u_p[\mathbf{boys}, c] \subseteq u_p[\mathbf{boys}, \mathbf{gather}, c]$
where $u_p[\mathbf{boys}, \mathbf{gather}, c]$
$= \bigcup\{G_{p'}(u) \,|\, p \preccurlyeq p' \wedge p' \in ([u]; \mathbf{atom}_{\text{assign}}\{u\}; \mathbf{boys}\{u\}; \mathbf{gather}\{u^{\oplus}\})\}$

b. $[\![\text{All}^u \text{ boys gathered}]\!]$
$= \lambda c_k\lambda s_i.\, s \in c \wedge \forall p \in s : u_p[\mathbf{boys}, c] \subseteq u_p[\mathbf{boys}, \mathbf{elect\text{-}the\text{-}president}, c]$, where
$u_p[\mathbf{boys}, \mathbf{gather}, c]$
$= \bigcup\{G_{p'}(u) \,|\, p \preccurlyeq p' \wedge p' \in ([u]; \mathbf{atom}_{\text{assign}}\{u\}; \mathbf{boys}\{u\}; \mathbf{elect\text{-}the\text{-}president}\{u\})\}$

[23] The entry will be slightly modified when we compare *dou* with *every* and *each* in the next chapter.

Note that although all^u involves $\textbf{atom}_{\text{assign}}\{u\}$ in order to retrieve the cardinality information, it doesn't prevent the nuclear scope predicate from taking a possibility-level argument - as in (109a), **gather** can still be applied to the sum $u^{\oplus}$ of possible assignments. Therefore, the update gets through as long as more than one boys in D_e are assigned to u. On the other hand, since **elect-the-president** is an assignment-level predicate, its plurality requirement renders to be a plurality requirement over each assignment, thus incompatible with the $\textbf{atom}_{\text{assign}}\{u\}$ condition instantiated previously, and the update is again inconsistent.

CHAPTER **4**

Inquisitiveness as Plurality

Let's put things together. Chapter 2 established the two components of the semantics of *dou*: the *plurality requirement* and the *distributivity effect*, and demonstrated how they can be adapted to explain the uses of *dou* as a distributor, a ∀-FC marker use and a scalar marker. Chapter 3 introduced Dynamic Inquisitive Semantics ($\mathsf{Inq}_{\mathrm{D}}$), in which two major enrichments to the original dynamic system—pluralities and questions—are coordinated into a unified framework. As mentioned above, these two subjects show a direct correspondence to the associates of *dou*, and it is worth exploring whether $\mathsf{Inq}_{\mathrm{D}}$ could provide us with novel perspectives on the semantic uniformity underlying the various use of *dou*.

The current chapter responds to the question above with a positive answer. In an attempt to translate the interpretations of *dou* associating with definite plurals and *wh*-words, we found that the *plurality requirement* of *dou*, though taking very different shapes in the static setting, can be rendered to different forms of inquisitiveness formalized in $\mathsf{Inq}_{\mathrm{D}}$. While in unconditionals and ∀-FC constructions the inquisitiveness is imposed on the antecedent question on the context level, *dou* associating with definite plurals seems to impose a possibility-level 'inquisitiveness'. The chapter will be structured as follows. Reversing the order in Chapter 2, the interpretation of *dou* in unconditional and ∀-FC constructions will be explored first in §4.1. Building on the intuition captured in §4.1, we will then try to capture *dou*'s association with definite plurals. A (non *ad hoc*) treatment for the scalar use of *dou*, unfortunately, will be left to future work, as focus interpretations would require further enrichment of the framework.

4.1 Unconditionals and ∀-FC: Context-level Inquisitiveness

In §2.2, we observed that Mandarin unconditionals and ∀-FC constructions share very close structures, both of which are embedded in the '*wúlùn...dou*' construction. We repeat examples (3a) and (42c) below as illustrations:

(3a) (Wúlùn) [shenme] shuiguo Yuehan *(dou) keyi chi.
(no-matter) what fruit John **dou** may eat.
'John may eat any fruit.'

(42c) (Wúlùn) paidui zai shui jia, Yuehan *(dou) keyi qu.
No-matter party at who house, John *(**dou**) may go.
'No matter whose house the party will be, John may go.'

In both cases, the presence of *dou* is obligatory, and the unconditional head *wúlùn* is optional. The only difference is while the unconditional antecedent in (42c) is a full question, the ∀-FC construction in (3a) contains only a *wh*-phrase '*shenme* (what) *shuiguo* (fruit)'. Further, we justified in §2.2.1.3 that *dou* indeed associates with the *wh*-question/phrase, and gave the following interpretation (49) (repeated from the same section) of *dou* in the '*wúlùn...dou*' constructions, written as dou_Q, based on $\mathsf{Inq_B}$.

(49) $$[\![dou_Q]\!]_c = \lambda P_T \lambda Q_T \lambda s_{st}.\ \underbrace{|\mathsf{alt}(Q_c)| > 1}_{\text{plurality}}.\ \underbrace{\forall \alpha \in \mathsf{alt}(Q_c) : s \subseteq [\alpha \Rightarrow \mathsf{info}(P_c)]}_{\text{distributivity effect}}$$

The entry spells out exactly how the plurality requirement and distributivity effect are instantiated. The former is imposed on the antecedent question and ensures its contextual inquisitiveness, and the latter is given in the form of a *lifted conditional* (see 2.11 for the definition) indicating that any resolution of the antecedent question Q will result in the same situation specified by the (non-inquisitive) consequent P. In particular, the distributivity effect imposed on each *alternative* of Q echoes the Hamblin-style analysis of unconditionals proposed by Rawlins (2013), and is able to derive the *orthogonality* between the antecedent and the corresponding consequent, which, according to Rawlins, is the key semantic contribution of an unconditional utterance.

Inspired by the above structural similarity, as well as Rawlin's hypothesis that FC effects can also be characterized as conveying *orthogonality*, we applied the unconditional analysis in the derivation of Mandarin ∀-FC constructions. In particular, we assumed that the *wh*-phrase headed by '*wúlùn*' functions as raising an *identity* question. Moreover, we made a conceptual modification regarding the location of *orthogonality*—we claim that instead of between the antecedent and the consequent, the *orthogonality* (conveyed by unconditionals) is actually between the antecedent and the whole proposition. These modifications help extend the coverage of *orthogonality* to 'donkey unconditionals' as in (51), and make it possible to formally define the orthogonality conveyed by FC constructions.

In §3.2.3.2, we introduced into the logical vocabulary an *identification operator* $?u$ raising the issue about the identity of the dref u. Functioning as an update function, it takes the input context c and returns those information states $s \in c$ whose possibilities p feature the same assignment to u from all the assignment functions in G_p (see Definition 97 and Fig. 3.4 for illustration). It should be clear at this point that the previous assumption of *wh*-phrase as an identity question was in fact inspired by the identification operator. Moreover, as discussed in the same section and exemplified in (98) and Fig. 3.4, it is in effect the identification operator $?u$ (and $?u$ only) that introduces the inquisitiveness into a *wh*-question. This observation is quite interesting, as it indicates that at least in the framework of $\mathsf{Inq_D}$, the plurality requirement of dou_Q is imposed on the same object, whether it's used in an unconditional or a ∀-FC construction (with *wh*-phrases). Moreover, as we will see in the discussion of *dou* associating with definite plurals, the plurality requirement can be captured with a counterpart of the identity question at the possibility-level. But before that, let's finish the section by extending the semantics of dou_Q to the language of $\mathsf{Inq_D}$. First we give the semantic sentence of lifted conditionals (*implications* in Dotlačil and Roelofsen, 2019) in $\mathsf{Inq_D}$. The notation '>' is overloaded here from Definition 2.11.

(110) $A_{(kk)} > B_{(kk)} := \lambda c_k \lambda s_i . s \in c \wedge \forall t \subseteq s : \forall t' \in A(c) \, [t \preccurlyeq t' \rightarrow t \preccurlyeq B(A(c))]$
$= \lambda c_k \lambda s_i . s \in c \wedge \forall \alpha \in \mathsf{alt}(A(\{s\}^{\downarrow})) : \alpha \preccurlyeq B(A(\{s\}^{\downarrow}))$, where

- $\{s\}^{\downarrow} := \{t \mid t \subseteq s\}$ denotes the downward-closure of s.

Note that here the notation alt follows the Definition 3.10 in $\mathsf{Inq}_{\mathrm{D}}$, whereas the one in (49) is its $\mathsf{Inq}_{\mathrm{B}}$ counterpart defined in Definition 2.2. The first line of the definition shows that $A_{(kk)} > B_{(kk)}$ updates an arbitrary context c to the (downward-closed) set of information states $s \in c$ where for any $t \subseteq s$ (thus t is also in the set), if t subsists in/supports the update $A(c)$, then it subsists in/supports the further update $B(A(c))$ as well. The second line rewrites the first line in terms of alternatives, namely, the update function $A > B$ takes those information states $s \in c$ whose 'local' update by A, i.e. $A(\{s\}^{\downarrow})$, supports the further update $B(A(\{s\}^{\downarrow}))$, where the downward closure $\{s\}^{\downarrow}$ of s is taken as the local context to be tested. Now we can give the semantic interpretation of dou_Q in $\mathsf{Inq}_{\mathrm{D}}$, as shown in (111)[24]:

(111) $$[\![dou_Q]\!] := \lambda P_{\mathbf{T}} \lambda Q_{\mathbf{T}} \lambda c_k \lambda s_i . \underbrace{|\mathsf{alt}(Q(c))| > 1}_{\text{plurality}} . s \in c \wedge \underbrace{\forall \alpha \in \mathsf{alt}(A(\{s\}^{\downarrow})) : \alpha \preccurlyeq B(A(\{s\}^{\downarrow}))}_{\text{distributivity effect}}$$

This (dynamic) interpretation of dou_Q derives the unconditional reading and ∀-FC reading of corresponding Mandarin constructions in almost the same way as (54), which is illustrated by the diagrams shown in Fig. (2.3). The only two differences are as follows. First, whereas the context c is a *relativized* notion based on which the antecedent and consequent propositions are evaluated, here it enters into the semantic composition directly. Second, whereas in the static system the identity of u is treated as a piece of world information that contributes to the identification of the actual world, in the dynamic system $\mathsf{Inq}_{\mathrm{D}}$, it is attributed to the discourse information. Therefore, the two-dimensional representation in Fig. (2.3) can be easily adapted to the dynamic setting where each black dot stands for a possibility and each row corresponds to an information state resolving the question $?u$.

4.2 Definite Plurals: Possibility-level Inquisitiveness

Let's now turn to the quantifier-distributor use of *dou*. In Chapter 2, we established that this use of *dou* can be characterized as a generalized distributor with a plurality requirement, following Lin (1998). We repeat the basic data (1) and the entry (11) for convenience.

(1) a. [Tamen] dou chi -le san-ge niuyouguo.
they **dou** eat -ASP three-CL avocado.
'They *all* ate three avocados.'

b. Tamen ba [san-ge niuyouguo] dou chi -le.
They BA three-CL avocado **dou** eat -ASP.
'They ate *all* of the three avocados.'

[24]The formal definition of presupposition in $\mathsf{Inq}_{\mathrm{D}}$ needs to be supplied. Here, we will stay informal and assume a Beaver-style notion of presuppositions in update semantics (Beaver, 2001), namely, presuppositions are pre-update checks that render update functions partial. For a treatment of presuppositions in inquisitive semantics, see e.g. Champollion et al. (2017b) and Schmitt (2018)

c. [Ta] (dou) chi -le san-ge niuyouguo.
He (**dou**) eat -ASP three-CL niuyouguo.
*'He ate three avocados (in one go).'/✓'He ate three avocados (every time he was here).'

d. *Scenario: On Sunday, Bill, Bob and Barbara rented a boat together and wandered around the canals in Amsterdam.*
[Tamen] (#dou) zu -le yi-sou chuan.
They (#**dou**) rent -ASP one-CL boat.
'They (#all) rented a boat.'

(11) Semantics of *dou*: Lin (1998)

$$[\![dou]\!] = \lambda P_{\langle e,st\rangle}\lambda x_e \lambda w_s.\ \underbrace{\exists C.Cov(x,C) \wedge |C| > 1}_{\text{plurality requirement}}.\ \underbrace{\forall y \in C : P(y)(w) = 1}_{\text{distributivity effect}}$$

As shown in (11), *dou* operates on a 'cover' C of its plural associate x_e, requiring the *plurality* of C (i.e. C is non-singleton), and distributes its predicate argument P over each element in C. Note such static treatment of generalized distributors (see also Lin, 1998; Schwarzschild, 1993) take the cover C to be a contextually-determined set. Moving to a dynamic setting where the notion of 'context' is formally characterized, follow-up questions arise as how the information about the cover is stored in the context, and what it means for it to be 'plural'. This section addresses these questions, and we will start with a look-back on *dou*'s association with definite plurals.

With the set-theoretically lifted dref assignment matrix treatment of discourse information, Brasoveanu (2008), followed by Dotlačil and Roelofsen (2019), is able to distinguish between two levels of plurality of a dref u w.r.t. a possibility $p = \langle w, G\rangle$, namely the assignment-level plurality and the possibility-level plurality,[25] for which we provide the following definitions:

Definition 4.1. (Assignment-level and Possibility-level Pluralities)

(i) A discourse referent u is *plural* on assignment level w.r.t. $p = \langle w, G\rangle$ iff for every $g \in G$, $g(u)$ is defined and is non-atomic.

(ii) A discourse referent u is *plural* on possibility level w.r.t. $p = \langle w, G\rangle$ iff for every $g \in G$, $g(u)$ is defined and $\oplus G(u)$ is non-atomic, where $\oplus G(u) := \oplus\{g(u) \mid g \in G\}$.

Note that the assignment-level plurality (asymmetrically) entails possibility-level plurality—if every assignment function $g \in G$ assigns a plural individual to u, then of course the sum of all the assignments from G to u will be plural. On the other hand, possibility-level plurality is compatible with assignment-level singularity (each $g \in G$ assigns u an atomic individual), as long as there are (at least) two different assignments to u from two functions $g, g' \in G$. Recall in the previous chapter we assumed that singular morphologies always give rise to atomic-level singularity; here it should be clarified that such correspondence doesn't hold between plural morphologies and atomic-level plurality, as shown directly by the plural reference to singular donkey anaphora in quantificational scopes:

[25] Brasoveanu (2008) phrased them as domain-level and discourse-level plurality, resp. In principle, we can further distinguish the state-level plurality based on Inq_D, but it's of little interest to our analysis.

(112) The teacher gave every^u student an$^{u'}$ avocado. They$_u$ ate them$_{u'}$.

As shown in (112), the single morphologies of *student* and *avocado* impose the assignment-level singularity to drefs u and u', yet they can still bind plural pronouns *they/them*.[26]

Now let's try to pin-point the plurality requirement of *dou*. We will first argue that neither assignment-level nor possibility-level plurality captures the essence of the plurality requirement of *dou*—the former is neither necessary nor sufficient, and the latter is not sufficient. Rather, as we will show after that, *dou* requires a *variation* at the possibility level. In the following, we will always assume the definite plural associated with *dou* carries the dref u. Meanwhile, since the above Definition 4.1 is given at the level of a possibility, we will process on a very simple context c (stay arbitrary for now) consisting of a singleton information state and $\emptyset$, say $c = \{\{\langle w^@, G\rangle\}, \emptyset\}$. In this case, for any update function A, c either supports A ($A(c) = c$, thus $c \preccurlyeq A(c)$), or contradicts it ($A(c) = c_\perp$).

The non-necessity of assignment-level plurality is manifested through example (113) below:

(113) Laoshi gei -le mei-ge^u tongxue yi-ge niuyouguo. [Tamen]$_u$ dou hen gaoxing.
Teacher give -ASP every-CL^u student one-CL avocado. [They]$_u$ **dou** very happy.
'The teacher gave every^u student an avocado. They$_u$ were all very happy.'

Same as singular morphologies in English, we assume the singular classifier *-ge* in *mei-ge* (every) enforces the assignment-level singularity of the dref u. Further, we assume the set of students consists of two atomic individuals a, b, and the teacher indeed gave an avocado to each of a and b at $w^@$. Then the context c will survive the update by the first sentence in (113), and additional discourse information will be added to c under the dref u, i.e. u turns active into $\mathbf{dom}(G)$, along with $g_1, g_2 \in G$ such that $g_1(u) = a$ and $g_2(u) = b$, as follows:

(114)

G	...	u	...
g_1	...	a	...
g_2	...	b	...
⋮		⋮	

Meanwhile, as we can see from (113), the plural pronoun *tamen* (they) can felicitously refer to the antecedent, while being the argument of *dou*. Therefore, the plurality requirement of *dou* can be satisfied even if its associate is singular on the assignment-level. Therefore, assignment-level plurality of u is *not necessary*.

The non-necessity of possibility-level plurality and the insufficiency of assignment-level plurality can be demonstrated through the same example:

(115) Si-ge^u ren zou -le jinlai. [Tamen]$_u$ (*dou) shi yi-zhi yaogun yuedui.
Four-CL^u people walk -ASP come-in. [They]$_u$ (***dou**) BE one-CL rock band.

[26] On the other hand, plural expressions usually correspond to possibility-level pluralities, as (112) seems only acceptable in the context where there are more than one students. However, note that *they* can also be used in (possibility-level) singular sense co-occurring with unspecified antecedent:

(1) Somebody^u left their umbrella in the office. Would they$_u$ please collect it?
(from Wikipedia, Singular they)

For this reason, we leave the possibility-level plurality out of the general semantic characterization.

'Four^u people walked in. They$_u$ are a rock band.'

Note that the presence of *dou* in the second clause will cause infelicity. According to the test given in (89), '*being a rock band*' should be an assignment-level collective predicate, as shown below:

(116) a. *Mei-ge ren dou shi yi-zhi yaogun yuedui.
Every-CL person **dou** BE one-CL rock band.
'*Every person is a rock band.'

b. *Suoyou ren dou shi yi-zhi yaogun yuedui.
All people **dou** BE one-CL rock band.
'*All the people are a rock band.'

That is, whether in Mandarin or English, '*shi yi-zhi yaogun yuedui*' (being-a-rock-band) is infelicitous[27] in the nuclear scope of *mei-ge* (every) and *suoyou* (all). Now consider $w^@$ is a world where there were indeed four people, say $\{a, b, c, d\}$, walking in, and they indeed form a rock band. Let's consider the update effect of each sentence. The first sentence 'four people walked in' will take c and return a context where u is added to the domain of G, where $\oplus G(u) = a \oplus b \oplus c \oplus d$. Meanwhile, the only possibility that can survive the second sentence (assuming without *dou*) is the one that assigns u the value $a \oplus b \oplus c \oplus d$ in a single assignment function g, as shown in (117a). On the other hand, for a possibility p' where $G_{p'}$ is set up as in (117b), since *being-a-rock-band* is an assignment-level predicate and $a \oplus b$, $c \oplus d$ do not form a rock band by themselves, such possibility will not survive the update.

(117) a.

G	...	u	...
g	...	$a \oplus b \oplus c \oplus d$	...
$\vdots$		$\vdots$	

b.

G	...	u	...
g_1	...	$a \oplus b$	...
g_2	...	$c \oplus d$	...
$\vdots$		$\vdots$	

Now, observe that u is plural on both assignment-level and possibility-level (the former entails the latter), yet the definite plural *tamen* (they) carrying it cannot be associated with *dou*. Since the sentence without *dou* is felicitous, we claim that the plurality requirement of *dou* is not satisfied here. Therefore, both assignment-level and possibility-level pluralities are insufficient.

What is the plurality requirement, then? Before finally answering it, we take one more extra step and consider the distributivity effect of *dou*. As a generalized distributor, *dou* does not categorically refuse predicates with collective readings. Consider a similar scenario as in (1d), with relevant utterances:

(118) *Scenario: On Sunday, Bill and Barbara rented a boat together and wandered around the canals in Amsterdam. So did Charlie and Celine.*

a. [Bier he Babala, Chali he Xilin] ?(dou) zu -le yi-sou chuan.
Bill and Babara, Charlie and Celine ?(**dou**) rent -ASP one-CL boat.
'Bill and Babara, Charlie and Celine both rented a boat.'

b. [Bier he Babala] (#dou) zu -le yi-sou chuan.
Bill and Babara (#**dou**) rent -ASP one-CL boat.
'Bill and Babara (#both) rented a boat.'

[27] Please ignore the presence of *dou* here, we will come back to this issue later. Importantly, the examples are the most common constructions of universal quantifications corresponding to *every* and *all*.

c. [Chali he Xilin] (#dou) zu -le yi-sou chuan.
Charlie and Celine (#**dou**) rent -ASP one-CL boat.
'Charlie and Celine (#both) rented a boat.'

In particular, as shown by (118a), as long as the predicate *'zu-le yi-sou chuan'* (rent-a-boat) can be distributively satisfied by *distinct* sub-groups of the plural individual denoted by the associate of *dou*, the presence of *dou* is acceptable. In fact, it is even preferred in (118a), probably in order to stress the existence of two distinct boats. Only when there is no distributive truth as in (118b) and (118c), the use of *dou* becomes infelicitous. In the current $\mathsf{Inq_D}$ framework (following PCDRT) where pluralities are captured with set of assignment functions, the only way to account for the distributivity effect is to take *dou* as enforcing an assignment-level evaluation; and if this is indeed the case, the above observation of the requirement of more than one *distinct* groups will correspond to the requirement that there are at least two assignment functions assigning different values to the dref, no matter the plurality/singularity feature of each assignment. As mentioned above, this characterization is very close to (the inquisitiveness) of the identification question $?u$, which picks out from the input context c those information states s such that for all possibilities $p \in s$, their dref matrices G_p agree on a unique assignment value to u among all assignment functions $g \in G_p$ (see (97) for the definition). Thus, each resolution to the issue $?u$ determines a fixed (possibly plural) individual that the dref u represents, and the inquisitiveness of $?u$ indicates multiple *distinct* individuals that can be assigned to u, just like the plurality requirement here. The only difference is that the inquisitiveness of $?u$ is defined on the context level, whereas the plurality requirement here seems to be imposed on the possibility-level.

Now we are in place to give the (first) semantic interpretation of *dou* based on $\mathsf{Inq_D}$. We resort to the distributive operator δ in deriving the distributivity effect, whose definition (106) is repeated below:

(106) $\delta_u := \lambda A_{kk} \lambda c_k \lambda s_i . s \in c \wedge \forall t \subseteq s \forall x_e : t_{u=x} \preccurlyeq A(\{t_{u=x}\})$, where

- $t_{u=x} := \{\langle w_p, G_{p,u=x}\rangle \mid p \in t \text{ and } G_{p,u=x} \neq \emptyset\}$
- $G_{p,u=x} := \{g \mid g \in G_p \text{ and } g(u) = x\}$

Putting things together, and following the previous account treating the plurality requirement as a presupposition based on $\mathsf{Inq_D}$ is given as follows:

(119) $$[\![dou]\!] = \lambda P_{r\mathbf{T}} \lambda v_r \lambda c_k \lambda s_i . \underbrace{\forall t \in c \, \forall p \in t : |G_p(v)| > 1}_{\text{plurality requirement}} . s \in c \wedge \underbrace{s \preccurlyeq \delta_v(P(v))(c)}_{\text{distributivity effect}}$$

where $G_p(u) := \{g(u) \mid g \in G_p\}$

Let's illustrate with the following simple example.

(120) [Tamen]$_u$ dou lai -le.
They$_u$ **dou** come -ASP.
'They$_u$ (all) came.'

The update effect of (120) is illustrated in Fig. (4.1). Let the subscripts of the world components stand for the individual(s) who actually came. Consider an input context with one alternative within which each possibility p has the same assignment matrix to u, containing g_1, g_2 such that $g_1(u) = a$ and $g_2(u) = b$. In such context, the plurality requirement of *dou* is satisfied, as every possibility corresponds to an assignment matrix with multiple distinct values assigned to u. The distributive operator δ_u combined with the update function **come**$\{u\}$ will then pick out the information states where each assignment of u satisfies the predicate.

Figure 4.1: Update effect of (120)

Finally, we show that the entry (119) predicts that *dou* does not clash with counting quantifiers such as '*suoyou*' (all) and '*dabufen*' (most), as discussed in §2.1.3.2. To demonstrate, let's take '*dabufen*' (most) as an example. Following Dotlačil and Roelofsen (2019), we assume the following semantics for *most*:

(121) $[\![\text{most}^u]\!] = \lambda P_{r\mathbf{T}} \lambda P'_{r\mathbf{T}} \lambda c_k \lambda s_i . s \in c \wedge \forall p \in s : \underline{|u_p[P,c] \cap u_p[P,P',c]| > |u_p[P,c] \setminus u_p[P,P',c]|}$, where

- $u_p[P,c] := \bigcup\{G_{p'}(u) \,|\, p \preccurlyeq p' \wedge p' \in ([u]; \mathbf{atom}_{\text{assign}}\{u\}; P(u))(c)\}$
- $u_p[P,P',c] := \bigcup\{G_{p'}(u) \,|\, p \preccurlyeq p' \wedge p' \in ([u]; \mathbf{atom}_{\text{assign}}\{u\}; P(u); P'(u))(c)\}$

The underlined condition inherits the static analysis of *most* as a generalized quantifier. Now consider the example below:

(122) Dabufen ren dou lai -le.
Most people **dou** come -ASP.
'Most people came.'

Mapping into (121), the restrictor predicate P will be *ren* (people) $\rightsquigarrow \lambda v_r.\, \mathbf{people}\{v\}$, and the nuclear scope predicate P' will be *lai* (come) $\rightsquigarrow \lambda v_r.\, \mathbf{come}\{v\}$ combined with *dou*. Since *dou* does not require assignment-level plurality as long as there are variations among each (singular) assignment, an application of (121) where the nuclear P' is combined with *dou* can go through. The resulting interpretation of (122), then, will be that the number of people who came is larger than the number of people who didn't (thus more than half), and there are at least two people who came (plurality requirement).[28]

[28] However, a puzzling fact is *dou* co-occurs with *most* even when combined with collective predicates (or predicates that don't accept singular argument), such as '*shi pengyou*' (be-friends) or '*juji qilai*' (gather up):

(1) a. (zheli) dabufen ren dou shi pengyou.
(Here) most people **dou** BE friend
'Most people (here) are friends.'

b. Dabufen ren dou juji -le qilai.
Most people **dou** gather -ASP up.
'Most people gathered up.'

The English counterpart can be captured by (121) as although u_p introduces assignment-level singularity to the new dref u, the predicates P, P' can still be collective and take the sum of the matrix assignment as argument. However in the Mandarin case, with *dou* enforcing distributivity, the nuclear scope predicate has to take each assignment value as argument, which yields inconsistency. This puzzle will be mostly left open, but see §4.3 for some more discussions.

4.3 Post-suppositional *Dou*, and other

In §2.1.2, a post-suppositional analysis (cf. Brasoveanu, 2012; Henderson, 2014; Champollion, 2015) was invoked in account for the co-occurrence of *dou* with distributive quantifiers like '*mei-ge*' (every) and '*gezi*' (each, but postnominal). The basic data is shown in (123). Note that we add an additional observation that the presence of *dou* is actually preferred in the nuclear scope predicate.

(123) a. [Mei-ge tongxue] ?(dou) lai -le.
Every-CL student (**dou**) come -ASP.
'Every student came.'

b. [Bier, Baobo he Babala] gezi (dou) hui jia -le.
Bill, Bob and Barbara each (**dou**) go-back home -ASP.
'Bill, Bob and Barbara (all) went back to home.'

The analysis given in §2.1.2 follows directly from Champollion (2015)'s analysis of the English sentence '*Every boy bought two sausages each*', where he claimed that the distributive force of the adnominal *each* is overloaded by that of *every*, thus *each* only functions as a 'post-suppositional plug' that ensures certain variation w.r.t. the at-issue content of the whole sentence, i.e. every boy bought *different* two sausages. The English data and the analysis served as a counter argument against those that claim *dou* does not carry a distributivity effect based on examples like (20).

In this section, based on the intuition obtained from §2.1.2, we explore the theoretical advantage of taking the plurality requirement of *dou* as a post-supposition. A post-supposition is typically construed as a post-update check that is plugged in only **after** the context has been updated by the at-issue content of the expression that contains their carriers. With the dynamic feature encoded in, systems such as Inq_D are thus able to formally express post-suppositional effect. However, the following discussion will proceed with the naive characterization of post-supposition given above, that is, we will take a post-supposition as an extra update merged to the end of the main update function. A formal definition of post-supposition in Inq_D has to be left for future investigations[29]. In the following, we write the post-suppositional *dou* as dou_{POST}, and highlight the post-supposition with the overline.

(124) $$[\![dou_{\text{POST}}]\!] = \lambda P_{r\mathbf{T}}\lambda v_r \lambda c_k \lambda s_i.\, s \in c \wedge s \preccurlyeq (P(v))(c) \wedge \overline{\forall p \in s : \underbrace{|G_p(v)| > 1}_{\text{plurality}}}$$

Note that here the distributivity effect of *dou* is omitted, analogous to the way *each* was treated in Champollion (2015), i.e. only as a dependent indefinite without introducing distributivity. Assuming the *dou* in (123) is in fact dou_{POST}, the update function expressed by (123a) can then be composed as follows. First, let's assume a similar interpretation of '*mei-ge*' as *every* in (107):

(125) $$[\![mei\text{-}ge^u]\!] = \lambda P_{r\mathbf{T}}\lambda P'_{r\mathbf{T}}.\, [u]; \mathbf{atom}_{\text{assign}}\{u\}; P(u); \mathbf{max}\{u\}; \delta_u(P'(u))$$

[29]Existing definitions of post-suppositions are predominantly based on Dynamic Semantics that define propositional truth conditions as *relations* between contexts, which makes it not so straightforward to adapt to update semantics where truth conditions are *functions* mapping contexts to contexts. However, see Charlow (2017) for an implementation of update semantics.

The only difference between (107) and (125) is that the latter requires additionally the assignment-level singularity. This is due to the presence of the singular classifier *-ge*. Thus in sentence (123a), '*mei-ge*' combining with '*tongxue*' (student) introduces a new dref u, whose assignment values are required to be an atomic student, and all the students in the domain should be assigned to u by at least one assignment function. Then it takes the nuclear scope predicate *dou lai -le* (**dou** came), and distributes it over each assignment value of u. Note that according to (124), dou_{POST} does not carry the distributivity effect, so at this point of the update, '*dou lai -le*' (**dou** came) is in effect identical to just '*lai -le*' (came). After that, the post-supposition carried by dou_{POST} (i.e. the plurality requirement defined in the previous sections) kicks in and checks if each assignment matrix assigns at least two different atomic students to u via two assignment functions. If they do, then the update context is accepted. Therefore, the final reading derived for (123a) is that all the students came, and it should be the case that there are more than one student, which is correct. Similar computation can be applied to (123b) to get the expected reading.

The characterization of the post-suppositional dou_{POST} leads to several interesting observations. The first one concerns the semantics of English *every*. As observed by Dotlačil and Roelofsen (2019), cross-sentential anaphora between a distributive quantifier and a singular pronoun is arguably unacceptable:

(126) ?Every^{u} book is on the table. It$_{u}$ is old.

However, this not predicted by $\mathsf{Inq}_{\mathrm{D}}$, as the singular morphology of *book* results in assignment-level atomicity of u, which is sufficient for u to be picked up by a singular pronoun. Dotlačil and Roelofsen (2019) thus made the following modification to the semantics of distributive quantifiers:

(127) Semantics of *each/every* (revised)
$[\![each/every]\!] = \lambda P_{r\mathbf{T}} \lambda P'_{r\mathbf{T}}. [u']; \neg\mathbf{atom}_{\text{assign}}\{u'\}; \text{dist}(P)(P')$, where

- $\text{dist}(P)(P') := \lambda c \lambda s.\, s \preccurlyeq ([u]; u^{\oplus} = u'; P(u); \mathbf{max}\{u\}; \delta_u(P'(u)))(c)$

This new definition defines *every/each* as *externally* introducing an assignment-level plural dref u', which *internally* corresponds to (the sum of) a (possibily) assignment-level singular dref u that carries the information about quantificational dependency. This explains the oddness of external singular reference to the dref introduced by *every*, as in (126). However, as mentioned by Dotlačil and Roelofsen (2019) in the same section, such modification in some sense loses the explanatory power w.r.t. telescoping/quantificational subordination (van den Berg et al., 1996; Poesio, 1995; Wang et al., 2006) where quantificational dependency might be picked up outside the scope of the distributive quantifier, as exemplified below:

(128) Every^{u} chess set comes with a$^{u'}$ spare pawn. It$_{u'}$ is taped to the top of the box.
(B. Partee, in Roberts, 1987)

The post-suppositional plurality requirement of *dou* indicates an alternative perspective. If we assume the English distributive quantifier *every* to behave not like '*mei*' (every) as defined in (107) or (125), but like the combination of '*mei*' (every) and *dou*, then we get the result that *every*, when combined with singular noun phrases, introduces an assignment-level atomic dref u, and meanwhile has a post-suppositional requirement that u is plural on the possibility level. If we further distinguish between cross-sentential anaphora into the ones that express quantificational dependency and the ones that do not, and assume the latter always agree with the antecedent on possibility-level singularity/plurality, then we can capture both the oddness of (126) and the felicity of (128).

Moreover, such characterization of distributive quantifier may in turn explain why the presence of *dou* is preferred in (123)—it is probably the case that distributive quantifiers will always correspond to possibility-level plurality, since otherwise it should be overtaken by simpler reference to the unique individual in its quantifying domain.

The second observation is that the semantic interpretation of dou_{POST} is compatible with the counting quantifier '*dabufen*' (most) when combining with (possibility-level) collective predicates. This is not so surprising—as discussed in footnote 28, such cases are problematic for the previous interpretation of *dou* in (119) because the distributive operator δ combined with a collective predicate clashes with the atomic individuals assigned to u. However, the entry (124) over-generates. The counter example can again be set the boat-renting scenario as in (1d).

(129) *Scenario: On Sunday, Bill, Bob and Barbara rented a boat together and wandered around the canals in Amsterdam, but Chris didn't.*

*Dabufen	ren	dou	zu	-le	yi-sou	chuan.
Most	people	**dou**	rent	-ASP	one-CL	boat.

?'Most people rented a boat.'

Just like in the original case, the use of *dou* is infelicitous. Before, we ascribed it to the violation of plurality requirement—there is only one boat being rented, and the distributivity effect of *dou* forces an assignment-level evaluation of the predicate '*rent a boat*', thus the only information states s that survive the update are those whose possibilities assign the sum of Bill, Bob and Barbara to the corresponding dref through every assignment function in the matrix, hence no variation on the possibility level. However, if *dou* is interpreted as dou_{POST}, the following assignment matrix (130) paired with a world w in which Bob,Bill and Barbara indeed rented a boat seems to support the update of (129) (assuming Bill, Bob, Barbara and Chris are the only individuals in the domain):

(130)

G	u
g_1	Bill
g_2	Bob
g_3	Barbara
g_4	Chris

For the possibility $\langle w, G\rangle$, it supports the update before the post-supposition, as three out of the four individuals assigned to u rented a boat together. It is evaluated on a possibility level as 'rent-a-boat' here has a collective reading, again because dou_{POST} no longer carries the distributivity effect that forces assignment-level evaluations. Meanwhile, the post-suppositional plurality requirement is satisfied, as G assigns different individuals to u through each assignment function. Moreover, this over-generation applies to general cases where *dou* is combined with (possibility-level) collective predicates. For instance, if Chris also joined the boat trip, then the following sentence (131) is also supported by the context shown in (130), if paired with a world in which they actually went on a boat trip together:

(131) *Scenario: On Sunday, Bill, Bob, Barbara and Chris rented a boat together and wandered around the canals in Amsterdam.*

Bier,	Baobo,	Babala	he	Kelisi	dou	zu	-le	yi-sou	chuan.
Bill,	Bob,	Barbara	and	Chris	**dou**	rent	-ASP	one-CL	boat.

'Bill, Bob, Barbara and Chris all rented a boat.'

However, just like (1d), the sentence is infelicitous in the current context. Should we just abandon dou_{POST} then? Maybe yes, but let's consider yet another possibility. The plurality requirement of *dou*, as demonstrated in the previous sections, can be intuitively construed as certain *inquisitiveness* showcased at different levels of the context—the plurality requirement imposed on unconditional antecedent or ∀-FC constructions features context-level inquisitiveness, whereas the one imposed on definite plurals features possibility-level inquisitiveness. However, the latter observation is drawn from the fact that *dou*, as a distributor, enforces assignment-level evaluations. In the case of dou_{POST}, however, no distributivity effect is assumed, and the evaluation of the predicate combined with *dou* can very-well be at the possibility level. Then it might be the case that we should also change the level of inquisitiveness corresponding to the plurality requirement of *dou* when it associates with collective predicates. In particular, we assume that in such cases, the plurality requirement renders to be the inquisitiveness at a **state-level** w.r.t. assignment matrices. A tentative modification is given in (132). We use the superscript '⊕' to signal possibility-level collective predicates.

(132) (Semantics of dou_{POST} with collective predicates)

$$[\![dou^{\oplus}_{\text{POST}}]\!] = \lambda P^{\oplus}_{r\mathbf{T}} \lambda v_r \lambda c_k \lambda s_i.\, s \in c \wedge s \preccurlyeq (P^{\oplus}(v))(c) \wedge \overline{\forall s : \underbrace{\exists p, p' \in s.\, w_p = w_{p'} \wedge \oplus G_p(v) \neq \oplus G_{p'}(v)}_{\text{plurality requirement}}}$$

Namely, the plurality requirement is satisfied only if there are at least two possibilities with the same world component whose assignment matrices assign different sum individuals to the dref under discussion. This modification resolves the above problem for plain definite plurals and the universal quantifier *all*. For instance, in the boat-renting scenario attached to (131), since the only (sum of) individuals that satisfies the predicate is Bill⊕Bob⊕Barbara⊕Chris (which is the sum of all the individuals in consideration), it is impossible to come up with another G with a different sum of its assignments (that also satisfies the predicate). However, (132) still over-generates when *dou* is in the nuclear scope of non-maximal quantifiers like *most*. Say we add another individual, Dave, into the boat-renting scenario. Then the sentence (129) is not only supported by the context represented by (130), but also the following:

(133) a.

G′	u
g_1	Bill
g_2	Bob
g_3	Barbara
g_4	Dave

b.

G″	u
g_1	Bill
g_2	Bob
g_3	Barbara
g_4	Chris
g_5	Dave

Since $\oplus G(u)$,$\oplus G'(u)$ and $\oplus G''(u)$ are different from each other, the plurality requirement is wrongly satisfied. We don't have a complete solution to this problem, but we suggest that the problem might be solved through a more 'local' notion of post-supposition. Namely, the post-suppositional plurality/inquisitiveness imposed by *dou* should be satisfied when the immediate subsequent predicate is being evaluated, rather than after the update by the whole sentence. If it is indeed the case, then since in the above scenario the predicate 'rent-a-boat' can only be satisfied by one plural individual, whether there are other people and no matter how many of them are there, it won't help salvage the violation of plurality requirement.

4.4 Remarks

Let's end this chapter with some general remarks. We found in this section that an implementation of the $\mathsf{Inq_D}$ framework brings further insights into the semantic core of the Mandarin particle *dou*. In particular, the *plurality requirement* of *dou* that are quite distinctively defined in Chapter 2 are manifested here as *inquisitiveness* at different levels of the context—in ∀-FC constructions and unconditionals it corresponds to context-level inquisitiveness, and in *dou*'s association with plural expressions it corresponds to possibility-level inquisitiveness. We further explored the possibility of defining the plurality requirement as a *post-supposition*, with the original purpose of explaining the co-occurrence of *dou* and distributive quantifiers like *mei-ge* (every). However, as we can see from §4.3, the post-suppositional analysis of *dou* not only realizes the original purpose, but also shows great potential in covering a much wider empirical landscape, at least for the quantifer-distributor use of *dou*. In the following discussion, we will refer to this characterization of the plurality requirement as a *post-suppositional inquisitiveness*.

Let's trace back a bit and reconsider the unconditional and ∀-FC constructions. In Chapter 2, we adhered to Rawlins (2013)'s idea in characterizing unconditionals, as well as free choice constructions, as conveying orthogonality. On the other hand, for the orthogonality to hold non-trivially, it seems necessary for the antecedent question to stay inquisitive/unanswered after the message. To be more precise, as unconditionals and ∀-FC constructions are usually used to express that certain conditions will hold *regardless*, it *won't help* in resolving the antecedent question, and the answer *wouldn't matter* either. This characterization is conceptually very similar to post-suppositional inquisitiveness, both to be construed as 'after the update, the question is still unresolved, (because it doesn't matter)'. Further, if post-suppositional inquisitiveness is indeed present in the semantic interpretations of free choice effect, it seems to provide a promising mechanism in accounting for the *licensing problem* w.r.t. various free choice items. For instance, it is commonly observed that free choice constructions in episodic context are at least deviant:

(134) a. *Any student came.
b. ?Shui dou lai -le.
who **dou** come -ASP.
Intended: 'Anyone came.'

Episodic sentences are typically used to state *facts* about some past event, and the utterance of such sentence indicates the *knowledge* of the speaker w.r.t. such information. Yet the factive knowledge of an event may block any kind of inquisitiveness. For instance in (134), imagine a scenario where the speaker is talking about a previous party and wants to express that 'everyone came'. However, knowing that 'everyone came' implies knowing 'who everyone is', e.g. the list of all guests. Then there is no real question about the identity of 'anyone'. Post-suppositional inquisitiveness doesn't satisfy, and orthogonality is trivialized. This idea is quite appealing, but a full-fledged proposal calls for a suitable framework incorporating modal notions. Thus hereby it is left for future works[30].

Finally, it should be noted that the post-suppositional analysis (124) does not pose any distributivity effect on *dou*. It raises the question of whether we really need distributivity effects to capture the semantic essence of *dou*. For unconditional or ∀-FC

[30]However, see Lauer (2009) for a post-suppositional analysis for *-ever*-like free choice items such as English *some*, Spanish *algún* and German *irgendein*.

constructions, the same question arises as whether a universal/distributive force is a necessary ingredient in the production of orthogonality, or it is just post-suppositional inquisitiveness that is needed. We leave the question open. But the (wonderful) irony should be highlighted, as we started off defending *dou* as a generalized distributor, yet end up questioning it ourselves.

CHAPTER 5

Conclusion and Outlook

The thesis presented a two-step investigation of the multi-functional Mandarin particle *dou*. The first step is an attempt to reach a conceptually uniform analysis of *dou* from its most basic use, i.e. as a quantifier-distributor. Building on Lin (1998)'s analysis of *dou* as a generalized distributor with a plurality requirement, we showed in Chapter 2 that this characterization can be extended to cover the other functions of *dou*. In doing so, we proposed a novel mechanism of deriving universal free choice effect, which stems from the analysis of unconditionals presented in Rawlins (2013). The second step is partially inspired by the first step—*dou* being able to associate with both plural noun phrases and inquisitive expressions drove us towards the implementation of Dynamic Inquisitive Semantics (Inq_D), where inquisitive and plurality informations are coordinated. As two interesting outcomes, Chapter 4 showed that the *plurality requirement* of *dou* can be characterized as *inquisitiveness* manifested on different levels, and a post-suppositional characterization of *dou* may be able to capture the quantifier-distributor use of *dou*.

The analysis of *dou* presented in Chapter 2 stands out from the previous approaches in the following aspects. First, in our account, *dou* is compositionally friendly, as the characterization of *dou* as a generalized distributor fits the impression that *dou* is always attached to the remnant VP in forming constituents. Meanwhile, the *leftness* condition, i.e. the fact that the NP-associate of *dou* is always on its left, can be simply accounted for by the common assumption that *dou* carries an [+EPP] feature. Second, our analysis of *dou* is intuitively approachable, as it stems from the characterization of its most common use. Also methodologically, it suggests a bottom up approach to the study of multi-functional particles in natural language might be fruitful—by formally grasping the common use, the variations may naturally follow.

The thesis is rich in future directions. First, our analysis of $\forall$-FC constructions follows the vision of Rawlins (2013) that unconditionals and free choice can be uniformly captured by the notion of orthogonality. It will be interesting to compare different instantiations of such vision (e.g. Szabolcsi, 2019) with cross-linguistic perspectives. Meanwhile, our analysis for unconditionals and free choice effect stopped at the derivation of the semantic effect, without further addressing their fine-grained modal implications, as well as their licensing conditions. Fortunately, within the dynamic framework featuring rich and flexible context information, further implementations seems approachable. Last but not least, as mentioned in the end of Chapter 4, whether *dou* carries a distributivity effect is after all questionable. This leads to more general questions as whether orthogonality (shown in Chapter 2 as derived by distributivity) requires a universal/distributive force, or just post-suppositional inquisitiveness. Further, if we consider the scalar reading, the question becomes whether the scalar feature is instantiated universally over the alternative set. As a final remark, the study of *dou* opens up the possibility of a large-scale connection between major subjects in formal semantics, and further investigations would surely bring us closer to the linguistic underlyings of logical reasoning.

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