A Note on Mohist Logic

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ABSTRACT. The paper is an exploration of the old Chinese texts called *the Mohist Canons* from a modern logical perspective. We mainly explain what the Mohists have contributed to logic in the following aspects: Theory on names, structures of propositions, patterns of reasoning, and theories on disputation and paradoxes. A comparative perspective is taken throughout the investigation. We compare Mohist logic and Western traditional and modern logic. We provide our new interpretations of the issues discussed in the Canons by applying the modern logical theories.
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1 Introduction

Aristotle's logic, especially the well-known 'Syllogistic', is often considered the first systematic formalization of basic logical issues. The Stoic school then made a further contribution through the development of propositional logic. This tradition of formalism has had an unparalleled impact on the history of Western thought, with a remarkable similarity in topics from Aristotle to Frege and Russell more than two thousand years later. Removing some camouflage, many of these issues are still of significance to our agenda today. Indeed, this tradition has led to the flowering of both traditional and modern logic in the West.

This paper, however, turns East, on a long journey back to Ancient China, and attempts to seek answers to the following questions. Have Chinese thinkers ever developed any logic similar to Aristotle or the Stoics?

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What sorts of reasoning were they using? What are the similarities and differences between the Chinese tradition and the Western one? What new understanding can we achieve by re-interpreting the relevant old Chinese texts with our modern logical theories?

Mozi and the Mohist Canons Logical themes occur in many philosophical works in Ancient China, such as the oldest text *the Book of Changes*, the works by the dominant Confucian school, and the texts of the Sophists, e.g. GongSun Long's well-known thesis 'A white horse is not a horse'. However, perhaps the greatest relevance and significance to logic is found in the school of Mohism, founded by a teacher named Mozi (Master Mo, his actual name was Mo Di (墨翟)), who lived during the fifth century B.C. Mozi was the first to challenge Confucianism by making reasoning the core of intellectual inquiry. The Mohist school was very influential during the Warring States period (479-221 B.C.).

The term *Mozi* is also used to refer to all works written by anonymous members of the Mohist school. These texts cover a great variety of topics: epistemology, geometry, optics, economics, and so on. Among them, there are six books, *Jing Shang* (经上), *Jing Xia* (经下), *Jing Shuo Shang* (经说上), *Jing Shuo Xia* (经说下), *Daqu* (大取) and *Xiaoqu* (小取). The collection of these six is usually called *The Mohist Canons*. For simplicity, we will sometimes call it the Canons in this context. *Jing Shuo Shang* is an explanation to *Jing Shang*, the same with *Jing Shuo Xia* and *Jing Shuo*. It is believed that *Daqu* was devoted to ethical issues, though there are major textual difficulties in understanding it. In this regard, *Xiaoqu* is much less problematic. It contains lots of logical topics, coherent and well-structured. (for a new attempt of re-translation and analysis of *Daqu* and *Xiaoqu*, see [16]). This paper will concentrate on these six books, although we will occasionally cite episodes from other books in the *Mozi*.

Research around *the Mohist Canons*, including its textual emendation, has been carried out in China, especially in the 20th century. As more and more logic books were being translated into Chinese in the early 20th century, *the Mohist Canons* also attracted more attention than before, witness the books and papers [18], [25], [26], [27], and more recently, [29], [31] and [33]. Outside of China, the Chinese scholar Hu Shi for the first time introduced Chinese Ancient logic in his dissertation [14] to the Western academic community. [10] provided a significant introduction to the above six books, despite the criticisms raised later by [9] and some other authors. Language and logic-related issues in Ancient China that are not restricted to the Canons have been discussed in [7], [11], [12] and many other works.

Aims and methodology Our aim in this paper is twofold. First, al-

though there is some research on the Canons both in China and abroad, unfortunately, over the last two decades there has been little interaction between the two sides. Recent research results in Mainland China are not truly recognized by scholars abroad, and the same is true vice versa. This paper is an attempt to fill this gap, and we will include some important current results from the Chinese literature. Second, we will focus on a new reading of the text of the Canons, and analyze it with relevant knowledge of modern logical theories, developing our own interpretation. Hopefully this will shed some new light on this old text.

We will use *modern logic* (including both its mathematical and philosophical aspects) as a tool to look at the issues considered by the Mohists. By itself, this approach to history is not new. Łukasiewicz adopted this perspective to read Aristotle's work in a new light, witness the title of his book [21]. And early in 1960s, the Polish sinologist Chmielewski advocated and used this methodology to study Chinese logic in his Series of papers entitled 'Notes on early Chinese Logic' (the first is [7]). Actually, like other scholars, we ourselves have used this method: [30] explored the logical thought in *the Books of Changes*, [19], [23] and [32] looked at Gongsun Long's works, especially his thesis 'a white horse is not a horse', and [20] used many-sorted logic to analyze the notion of 'class' in Mohist logic. The present paper continues this line – and we will make a few more detailed comments later in our discussion of reasoning patterns about what such modern interpretations achieve.

Moreover, we will take a *comparative perspective* throughout our investigation. We compare Mohist logic and Western traditional and modern logic, with a focus only on logical theoretical aspects. However, we are aware of the differences in other regards, e.g., Western traditional logic is ontological oriented while Mohist logic is more argumentation-oriented. Two facts are important to keep in mind here. First, Mohist logic did not survive in the Chinese history, and so it is hard to find a consistent development of it. Second, the logics that were studied in subsequent centuries in China were mostly imported. For instance, Buddhist logic was introduced from India during the Tang Dynasty (618-907 A.D), Western logic became popular starting from the 17th century[1]. More logic books were translated at the start of the 20th century.

The paper is structured as follows. Section 2 is about the classical topic of the correct use of 'names'. We look at the syntactic and semantics aspects of names as studied by the Mohists, and especially their use of variables. Section 3 considers the many kinds of propositions and the logical constants

[1]The first translation of Euclides' *Elements of Geometry* by the Jesuit Matteo Ricci and a Chinese scientist Guangqi Xu appeared in 1607.

that existed in the Canons. Section 4 has a focus on reasoning, in particular, we will try to enhance our understanding of some key reasoning patterns, such as *parallelizing*. Section 5 explores what are the basic logical laws one has to follow in a disputation, and what is the purpose of a disputation. Section 6 discusses several paradoxes found in the Canons. We summarize our main conclusions in Section 7.

2 Names and variables

2.1 Genus and differentia

"Name (*ming*)(名)" is one of the most important notions in Ancient Chinese philosophy. The issue of 'rectification of names' has been a core theme for many schools in the pre-Qin period, which provided rules of how to use names correctly, and also how to correct wrong usage. The contribution of the Mohists in this respect is their discussion of many of these issues at an abstract meta-level. We first review their basic theory of language use.

"*Yiming jushi*(以名举实)"(NO 11)[2] says 'one uses names to refer to objects'. To give a name to some object, there are two basic things to consider, namely, "like (*ruo*)(若)" and "so (*ran*)(然)". These two things determine 'standard', so called *fa* (法), namely, "that in being like which something is so" (A 70). So, in order to use one name consistently, we must follow *fa*. E.g., the name of 'circle' can be applied to the compass, too, since it fits the same standard (A 70).

Names can be of different kinds, as described in "There are three kinds of names: unrestricted names, classifying names and private names"(*ming. da, lei, si.*)(名。达，类，私。)(A 78). For instance, 'thing' is 'unrestricted', as any object necessarily requires this name. 'Horse' is a 'classifying' name, for anything 'like the object' we necessarily use this name. The name 'Jack' is a 'private' name, as the name stays confined to this object. This is a classification of names from an extensional point of view, as the denotations of the three kinds go from the whole universe to a single object. It seems that only 'thing' falls into the category of unrestricted names. Classifying names are the most common ones people use, they are what we would call generic names or predicates nowadays. And private names are simply what we would now call proper names.

Most importantly, the Mohists proposed principles regarding the distinction between any two classifying names. In fact, this follows from the notion

[2] In this paper we follow Graham's numbering of the Canons. He made a hybrid text from *Xiaoqu* and part of *Daqu* under the title "Names and Objects"(abbreviated 'NO') and most of the remainder of *Daqu* as "Expounding the Canons"('EC', for short). 'TC' and 'HC' abbreviate *Daqu* and *Xiaoqu*, respectively. We will make some revisions of Graham's translation where necessary.

of 'standard' we have seen above. They say that proposing a 'standard' is not arbitrary, we have to pick those properties which one object has and the other lacks. In other words, the properties have to help us differentiate two kinds of objects. This view on the correct use of classifying predicates is elaborated in the following passage, which contains a nice example too:

> By referring arbitrarily one cannot know differences. Explained by: what they have. Although oxen are different from horses, it is inadmissible to use oxen having incisors and horses having tails as proof that oxen are not horses; these are things which they both have, not things which one has and the other lacks. (B 66)

To distinguish oxen from horses, we should pick those properties which one has and the other lacks, but having incisors and having tails are not the properties of this kind. We will come back to this issue again when the kind-based reasoning is discussed in Section 4. This is very similar to what Aristotle proposed. According to Aristotle, a *species* is defined by giving its *genus* and its *differentia*: the genus is the kind under which the species falls, and the differentia states what characterizes the species within that genus. It is species that have *essence* which should be the base of a correct definition. The notion of essence is similar to *fa* in Mohist logic. The example in the above text shows that oxen and horses belong to the same kind 'animal', and one should find a *fa* for each species that differentiates one from another within the same kind. We can fairly say that the theory of classifying names by Mohists had the same spirit as Aristotle's account of 'genus and differentia'.

Regarding the relationship between names and objects, the Mohists claim that different names can be used for the same object, and different objects can share the same name. A good example for the former is that the dog is an object with two names, *quan* (犬) and *gou* (狗). For the latter, according to the given standard, objects sharing the same name are not necessarily alike except in the respects covered by the standard. For example, pieces of stone and of wood both of which fit the standard for 'square' share the same name 'square'. This statement on the relationship between names and objects suggest that the Mohists realized that there is a distinction between *syntax* and *semantics*, as one would state it in our modern terminology. The same point was made by Frege at the beginning of the 20th century. Doesn't the example of *quan* and *gou* remind us of Frege's famous discussion of 'the morning star' and 'the evening star'? As we know, 'the morning star' and 'the evening star' are two different names, but they refer to one and the same object, the planet Venus.

2.2 Use of variables

The issue of whether variables were used in Mohist logic has been a point of controversy. The importance of this question goes without saying, as we know what a central role variables have played in logic. They are an indicator of true insight into general formalism. In what follows, we will streamline some observations on this topic from the earlier literature. In particular, we will state some new insights by Chinese scholars that have not yet been fully appreciated elsewhere.

Harbsmeier has a positive view on Mohist uses of variables in [12]. His example is the following:

> In case of naming on the basis of shape and characteristics, we necessarily (*bi*) know that this thing is *X* (*mou*), only then do we know *X* (*mou*). In cases where naming cannot be on the basis of shape and characteristics, we may know *X* (*mou*) even if we do not know that this thing is *X* (*mou*). (NO 2)

Harbsmeier thinks that "the use of *mou* (某) came closest to the use of variables". As we understand the matter, *mou* in the above text can be read as 'something': it is an indefinite pronoun that can refer to something identifiable but as yet with no specific name. What is special about an indefinite pronoun is that it has no properties that one can recognize as belonging to a particular thing, but one can replace it with a particular name given a specific context. This is what is usually meant by variables. The word *mou* is used in a similar way even in the modern Chinese language. E.g., 'mou ren' (某人) means 'someone', and 'mou wu' (某物) means 'something'.

One more example was considered in [31] and [33] concerning Mohist usage of variables. It involves the two demonstrative pronouns, "that (*bi*)(彼)" and "this(*ci*)(此)". Just like *mou*, both of them are used very much like variables. Consider the following text:

> It is admissible for the man who uses names rightly to use 'that' for this and 'this' for that. As long as his use of 'that' for that stays confined to that, and his use of 'this' for this stays confined to this, it is inadmissible to use 'that' for this. (B 68)

Clearly, in the preceding text 'that' and 'this' are used to denote two different names. Roughly speaking, in order to use names correctly, one has to make a distinction between 'that' and 'this'. Confusion is not allowed.

So here the demonstrative pronouns 'that' and 'this' are just two symbols (and hence once again, variables) of two different names. [3]

A somewhat striking further observation was also made in [31]. As we have noticed from reading the Canons, the names "ox (*niu*)(牛)" and "horse (*ma*)(馬)" have been used very frequently to explain things in situations which have nothing to do with the animal *niu* and *ma* themselves. For instance, let's read the following text:

> *niu* is a single name, and *ma* is a single name too. However, *niu-ma* is a compound name. It is not the same as *niu*, nor the same as *ma*. (B 67)

Here the point is the difference between *niu-ma*, as a compound name and *niu* or *ma* as a single name, rather than stating anything concrete about *niu* or *ma* itself. This text is meant to explain what is a compound name. Clearly, this is a generic explanation, and the two specific predicates are being used as variables!

There are many other places where *niu* or *ma* occurs in the Canons. With this new interpretation in mind, it should be easier to understand some of the texts. Take the following example: *"One calling it 'ox' and the other 'non-ox' is contending over claims which are the converse of each other".* (A 74). This talks about a disputation. From a logical point of view *ox* (P) and *non-ox* ($\neg P$) are used to express two contradictory predicates or propositions, and one of them should come out through disputation. To us, this passage suggests that *ox* almost serves as a propositional variable.

Surprisingly, we can find this use of variables even earlier: in the work of the Sophist Gongsun Long. As we know, Gongsun Long proposed the famous thesis 'a white horse is not a horse', which was challenged by the pupils of Confucius. Let us look at how he defended it. He said: "Why would it be a problem to say 'a white horse is not a horse' if we accepted what Confucius said 'Chu's man is not a man'?" Clearly, what he took for granted is that his thesis is not about a particular statement involving a white horse and a horse, but about all propositions of that form, where 'horse' can be substituted for by other names. Thus, the idea of variables and schematic assertions existed even before the Mohists.

In the above we have shown the similarity between Mohist views of names and those of Aristotle and Frege. We have seen that the indefinite pronoun

[3] [31] made an attempt to interpret this in terms of set-theoretic operations:

That $\cup$ That= That.

That $\cup$ This $\neq$ That.

mou, the two demonstrative pronouns *that* and *this*, and even the specific predicates *horse* and *ox* were used as variables in the Canons. Furthermore, we showed that the idea of variables can be pushed even back to the Sophist's period before the Mohists. This use of variables reflects the effort Mohists made toward formalism. To do so, they appeal to natural language while taking some particular words as variables. A similar approach occurs in Stoic logic, where the ordinal expressions 'the first' and 'the second' were used as propositional variables. It is also reminiscent of medieval Scholastic practices of using recurrent routine examples as variable 'patterns' rather than specific assertions.

3 Propositions and logical constants

We now turn to the structure of logically complex propositions.

As "*yichi shuyi* (以辞抒意)" (NO 11) says, propositions are used to elucidate ideas[4]. We express our ideas by means of various types of proposition. The Canons discussed different types of proposition involving logical constructions like quantifiers, conditionals and modalities. Since there is no systematic categorical classification of propositions in the Canons, in what follows we are going to review it based on our modern view of the matter. Along the way, we will pay attention to how Mohists perceived differences between the propositional types, and especially how they use logical constants to indicate these types in the language.

Quantifiers: all and some The universal quantifier is expressed by the word "all (*jin*)(尽)". As explained in "all is none not being so" (*jin, mo buran ye.*)(尽，莫不然也。) (A 43). Written in a logical formula, it is $\forall x = \neg\exists x\neg$. Notice that here *jin* is defined in terms of "none (*mo*)(莫)" which is taken as a primitive; and thus, the universal quantifier is defined by a double negation. Besides *jin*, other words, like 俱(*ju*), 周(*zhou*), 盈(*ying*), 遍(*bian*), are often used to express the universal quantifier, they all mean 'all'. One can easily find propositions containing such words in the Canons. The negation of the universal quantifier is defined as well: in "some is not all"(*huoyezhe, bujin ye.*)(或也者不尽也。)(NO 5 HC 6B/3-5). Put again in a logical formula, we get $\exists x = \neg\forall x$. This is not really what existential quantifiers mean nowadays ($\exists x = \neg\forall x\neg$.). Probably the Mohist text is not a definition, but it wants to make the point that 'some' (viewed as a part) differs from 'all' (as the whole).

Disjunctions, conjunctions and conditionals The expressions "either... or... (*huo... huo...*)(或...或...)" are used to express disjunction in

[4]The translation by Graham was 'propositions are used to dredge out ideas'.

the Canons. Of the many examples in our texts, we only give two for the purpose of illustration: "either call it ox, or call it non-ox" (A 74), and "either its body is gone or it is still here." (A 46).

Concerning conjunctions, it seems that there is no clear sign for this in the language, but the Canons have many propositions which express the idea that several things should hold at the same time. Probably, juxtaposition was seen as implicit conjunction. [5]

The conditional is defined in 'the loan-named is not now so' (*jiazhe, jin buran ye.*)("假者今不然也。")(NO 5 HC 6B/3-5). Conditions or causes that lead to some phenomenon are called "reason (*gu*) (故)". There are two types of *gu*, "major reason (*da gu*)(大故)" and "minor reason (*xiao gu*)(小故)". The distinction between them is illustrated in the following text:

> The gu of something is what it must get before it will come out. Minor reason: having this, it will not necessarily be so; lacking this, necessarily it will not be so. It is the unit, like having a starting-point. Major reason: having this, it will necessarily be so; lacking this, necessarily it will not be so. Like the appearing bringing about the seeing. (A1)

According to the above explanation, *major reason* and *minor reason* are actually what we nowadays call 'sufficient and necessary condition' and 'necessary condition', respectively. In the Mohist texts, 'if...then...' (*ruo...ze*)[6] (若...则...) are often seen to express conditionals.

Modalities Interestingly, modalities are considered in the Canons too. First, the word " 必(*bi*)" is used to express *necessity*. For instance, "There necessarily exists a winner in a disputation" (*Wei bian wusheng, bi budang.*)(谓辩无胜，必不当)(B 35). Several tensed modalities are also considered. The word 且(*qie*) is used to express the future tense. E.g., in "Going out in the future is not going out now"(*qie chumen, fei chumen ye.*) (且出门，非出门也。), we can see two states of going out in the future or going out now are clearly distinguished. Likewise, " 已(*yi*)" is used to denote the past tense in the language. As shown from those examples, modalities are explicitly recognized as such in the text of the Canons.

Complex propositions One striking phenomenon is that the Canons are replete with complex propositions such as "riding a white horse is riding a horse", "killing a thief is not killing a man", etc. They are not simply constructed from basic propositions by means of the logical constants we have seen so far. In addition, they have much richer variations in complex

[5] [33] proposed that 盈 (which really means 'all') can be seen as a conjunction sign.
[6] sometimes 'ruo' is omitted when it is clear from the context

predicates. Thus, reasoning with complex propositions is more complicated, as will be explored in Section 4 below. To conclude, we only mention one logical issue here relevant to the complex propositions, namely, that of extension of predicates, which is the basis of all correct reasoning with complex propositions. To illustrate this, consider the following example:

> 'He loves people' requires him to love all people without exception, only then is he deemed to love people. 'He does not love people' does not require that he loves no people at all; he does not love all without exception, and by this criterion is deemed not to love people. ... These are cases in which something 'applies without exception in one case but not in the other'. (NO 17)

This text shows that considering the correct application of certain predicates is exactly to spell out their extensions. This is a crucial topic in logic. We will come back to this point in the next section.

Remark The diversity of propositions considered by the Mohists involves different indicators in the language, e.g. 'huo... huo...' for disjunctions. The clear identification of those structuring expressions suggests that the Mohists realized the distinction between logical and non-logical expressions. The former are the protagonists of modern logic, and they determine logical structures in general. Consider two examples we have seen: "或谓之牛，或谓之非牛(*huo weizhiniu, huo weizhi feiniu*)", and "其体或去或存(*qiti huoqu huocun*)". They have the same logical form "或...或... (huo..., huo...)", but are about different subject matters. As we know, Stoic logic contributed much to the study of propositional logic, especially in their work on conditionals. In its emphasis on propositional sentence structure, Mohist logic seems closer to Stoic logic than to Aristotle.

4 Reasoning

4.1 Sources of knowledge

The word "说(*shuo*)" means 'clarification of a statement', as defined in "the means by which one makes plain" (*suoyi ming ye*)(所以明也)(A 72). From this initial meaning, *shuo* gets its further meaning which refers to reasoning or providing proofs, as in "by means of explanations bring out reasons" (*yishuo chugu*)(“以说出故”)(NO 11).

This point becomes much clearer when the sources of knowledge are discussed. The Canons say "There are three different ways to get knowledge: viz. learning from others, reasoning from what one knows already, and consulting one's own experience." (*zhi: wen, shuo, qin*)(“知：闻，说，亲。”)

(A 80). This clearly identifies the different ways of getting knowledge – and besides, a nice example is also given to show these different sources plus their interplay. It goes as follows: Imagine that someone, say Jack, is standing outside of a room, and he sees an object which is white. From the very beginning then, he knows from his own observation that 'the object outside of the room is white'. But now, there is another object, inside the room, of a yet unknown color. Now Jack is told that the object in the room has the same color as the one outside. Now he knows that 'the object in the room has the same color as the one outside', by learning from others. Finally he also knows that 'the object in the room is white', via his own reasoning based on what he knows. This example illustrates exactly how *shuo* works for us when we acquire knowledge. Our exploration of *shuo* in this section will be based mainly on its meaning of 'reasoning'.

4.2 Patterns of reasoning

To get to know something by means of *shuo*, we can appeal to many different kinds of reasoning. This section is about reasoning patterns in the Mohist texts. Our focus are the characteristics of these patterns and their validity.

We will start with a simple pattern called *Xiao*, as explained in the following text from *Xiaoqu*:

> The *xiao* consists of setting up the *fa* (standard). That which things are modeled after is that which is to be set up as the *fa*. When it conforms to the *xiao*, it is right. When it does not conform to the *xiao*, it is wrong. (NO 5)

The name used for the reasoning here is called *Xiao* (效) which means 'to imitate'. The above text explained how the reasoning of Xiao is carried out. First, a general standard (*fa*)(法) is set up, which gives us some general principles to follow in the inference. Next, according to the standard, we infer whether specific things conform to this standard or not. Namely, if the specific thing conforms to the standard, we say it is right, otherwise, it is wrong. We can see that this reasoning goes from a general rule or standard to specific cases. It is similar to the following example which we are so familiar with: "All human beings are mortal, Socrates is a human being, so Socrates is mortal". In this example, the standard is "All human beings are mortal", then we infer whether a specific human being Socrates conforms to this standard. In this sense, Xiao can be thought of as a *deduction*.

In what follows, we continue with a few more central patterns that occurred in *Xiaoqu* as well: "Illustrating (*pi*)(辟)", "Adducing (*yuan*)(援)", "Inferring (*tui*)(推)" and "parallelizing (*mou*)(侔)". We explain the reasoning by concrete examples, and then try to analyze it in terms of logical rules.

In particular, in our final subsection, we apply some results from what is sometimes called 'natural logic' (monotonicity reasoning) to the pattern of 'parallelizing', which abounds in the Canons.

4.3 *Kind*-based reasoning

We first consider the three reasoning patterns of illustrating, adducing and inferring in this subsection. Let us point out straightaway that these have a feature in common, namely, their validity is based on a notion of "*kind* (*lei*)(类)". Before looking further into each specific pattern, we first give some analysis of this underlying notion. *Kind* is one of the core concepts in Mohist logic, and it serves as a basis for much logical reasoning. Together with "evidence (*gu*)(故)" and "general law (*li*)(理)", it forms the *three basic components* of a piece of reasoning.

As we have seen in Section 2, classifying names are those names that are supposed to apply to *kinds*. We discussed not only the rules of correctly using classifying names, but also the principles governing the distinction between any two classifying names. Recall our example: 'horse' is a 'classifying' name, for anything 'like the object' we necessarily use this name. More generally, the following view underlies the Mohist account:

> (a) For each *kind*, there are objects which belong to it, and in virtue of this, they are *similar* or *the same*.
>
> (b) With each *kind*, there are some properties which are *essential*, being common to all the objects.

The similarity between objects of the same kind is called "the sameness of the kind" (*leitong*)(类同). Many different sorts of similarity are discussed in the Canons, but the sameness of the same kind is clearly distinguished from other sorts, witness the text below:

> Same. Identical, as unites, as together, of a kind. There being two names but one object is the sameness of 'identity'. Not being outside the total is sameness 'as units'. Both occupying the room is the sameness of being 'together'. Being the same in some respect is sameness in being 'of a kind'. (A 86)

Objects that are being of a same kind have common essential properties, called 'leitong'. In addition, the Canons also discussed *difference in kinds*. Again, there are many sorts of difference, but "difference in kinds (*leiyi*)(类异)" is the one that is relevant to our discussion here. It says: "different. ..., not same in a certain respect is 'not of a kind' (*yi: ..., buyoutong, buleiye.*)(异: ..., 不有同，不类也。)"(A 87).

From the above, what matters to a kind is its essential properties. They are the criterion by which a kind is identified. Moreover, according to these properties, we can determine whether an object is of that kind or not. Accordingly, objects that belong to one kind have similar properties. Put more formally,

> Let the essential property of some kind be denoted by P. If A and A' are two members of that kind, then A has the property P iff A' has the property P.

It will become clear how this view is exploited concretely as we continue our study of reasoning patterns.

Illustrating (*pi*) "Illustrating is that, in order to make someone else know one thing, you refer to a different thing known by him already." (*piyezhe, jutawu yi mingzhi ye.*)("辟也者，举他物而以明之也。")(NO 11) In fact, this pattern of reasoning originated in works much earlier than the Canons, like the 'Book of Odes' around 1000 B.C. A well-known Sophist Hui Shi (380-305 B.C.) is also famous for his talent in using this sort of reasoning in his arguments. The feature of illustrating is that two different things A and A' are used in the reasoning. The reason why one can get to know A by appealing to a different A' lies in the similarity between A and A', as introduced in the above.

To see this, let us look at the example from the book *Gongshu* of *Mozi*: Mozi met the King of the State Chu. In order to convince the King that it is not right for the rich Chu to invade the poor State Song despite being wealthy, he used a more obvious example. Namely, it is not right for rich people to leave their property behind and go robbing poor people. Since the King sees the injustice of the latter, he realizes that of the former, too. Clearly, in this example, (a) the wealthy State invading the poor State, and (a') the rich people robbing the poor, are of the same kind. As it is easy to see the injustice of (a'), one can then infer the injustice of (a) too. Notice that the purpose of illustrating is to make someone else know, not to make oneself know. In this sense, it is more like the process of explanation – and also, it is a typical illustration of the interactive argumentative slant that can be found in the Canons.

Adducing (*yuan*) "Adducing means: if it is so in your case, why may it not be so in mine too?" (*yuanyezhe, yue: ziran woxidu bukeyiran ye?*)("援也者，曰:子然我奚独不可以然也?")(NO 11) Adducing is carried out in the following steps: one first quotes the opinion that the opponent accepts, then one argues that the opponent's opinion and one's own opinion are the same or belong to the same *kind* (*lei*)(类). Then, it naturally follows that one's

opinion should be accepted as well, *if* the opponent insists on his opinion. We mentioned one example in Section 2, when Gongsun Long defended his thesis 'a white horse is not a horse'. The argument used there is 'Adducing'. He asked why it would be a problem for him to say 'a white horse is not a horse' if we accepted what Confucius said: 'Chu's man is not a man'.

Again, the basis of adducing is *kind*. In the above example, 'Chu's man is not a man' and 'a white horse is not a horse' are of the same kind, hence if one of them true, the other should be true as well. In fact, both illustrating and adducing can be formalized into the following schema:

(i) Object or statement A and A' are of the same kind (i.e. A has the kind-defining property P iff A' has that property P),

(ii) A has the property P,

(iii) Therefore, A' has the property P.

As we can see from the above examples, premise (i), considered to be common knowledge, is often omitted from the reasoning. What is left then is a transition of some property from one object or statement to another object or statement that is of the same kind. But of course, establishing the sameness in kind is an essential feature in practice.

Inferring (*tui*) "To 'infer' is to present him on the grounds of a similarity between what he does not accept and what he does accept" "推也者，以其所不取之同于其所取者，予之也。" (*tuiyezhe, yiqi suobuqu zhitongyu qisuoquzhe, yuzhiye.*)(NO 11). Let us consider the following scenario. If someone proposes a statement you do not agree with, what you need to do is choose a statement which belongs to the same kind as what he proposed (and which he should therefore accept), but in fact he cannot accept it. In that case, he has to give up his initial statement. This describes precisely how inferring proceeds. Let us look at the following example in the book *Gongmeng* of *Mozi*: Mencius [7] does not think gods or ghosts exists, but nevertheless, he claims that gentlemen(*jun zi*)(君子) should learn how to pray. Mozi then says: 'What Mencius said is just like saying you have to learn how to treat your guests well, but there is no guest at all. This is also like having to make a fish net, but there is no fish.' The absurdity of the last two cases is clear, so we conclude that what Mencius said was wrong.

In this example, what Mencius said about gods and what Mozi said about guests or fish are of the same kind. Apparently, Mencius could not agree with the statement about guests and fish, so his statement about gods can also be rejected. The logical reasoning pattern here is this:

[7] Mencius (372-289 B.C.) was the most famous Confucian after Confucius himself.

(i) Object or statement A and A' are of the same kind (i.e. A has property P iff A' has property P),

(ii) A' does not have the property P,

(iii) Therefore, A does not have the property P.

This style of reasoning is very common in practice if one wants to reject some statement proposed by others.

So far, our analysis has shown that in illustrating, adducing and inferring, by comparing two objects (or statements) of the same kind, we infer that one of them has (or lacks) some property from the fact that another has (or lacks) that property. This sort of reasoning is generally called "analogical inference (*leibi tuili*)(类比推理)".

We now discuss this reasoning in a bit more detail. First, looking at the final patterns of argument from a premise about similarity plus one about an object having or lacking some property, we see two valid schemas of the propositional logic of conditional reasoning. Illustrating and adducing are both of the form:

(i)$\phi \leftrightarrow \psi$,

(ii) ϕ,

(iii) Therefore, ψ.

And inferring has the following related format:

(i)$\phi \leftrightarrow \psi$,

(ii) $\neg\psi$,

(iii) Therefore, $\neg\phi$.

Next, more can be said about the 'analogy premises' themselves, which remains unanalyzed when we just look at the propositional over-all form. These premises may be viewed as short-hand for the following more complex inference pattern:

(i) Situation C is like situation C' (they all share some relevant property Q),

(ii) Proposition A holds in situation C,

(iii) Therefore, proposition A' holds in C'.

where A' is some assertion that forms the natural counterpart in C' of the assertion A in C. Obviously, the strength of this reasoning depends both on

the strength of the similarity between the two situations C, C' established by the shared property Q, and the nature of the analogy between the two assertions A and A'.

We will not pursue this matter in more depth here, but we feel that much Mohist reasoning involves a mixture of purely logical inference plus an appeal to similarity between situations, allowing us to use facts about one to learn new facts about another. This feature is reminiscent of the role of 'context' noted for Indian Logic in [6], who point at analogies with current 'situation theory' ([1]), which is about information flow between suitably connected situations.

4.4 Parallelizing (*mou*): Several cases

Having stated this general analysis, we now turn to a final set of patterns in the Mohist texts which we find most striking as immediate analogues of the logical reasoning studied in the western tradition.

The relevant pattern is explained in "parallelizing is comparing propositions and then letting all 'proceed'" (*mouyezhe, bichi er juxingye.*)("侔也者，比辞而俱行也。")(NO 11). Note that this style of reasoning involves the complex propositions discussed in our previous section. Three concrete varieties of this kind of reasoning are considered in the Canons. We will look at each in what follows, and try to propose a new interpretation, coming from the perspective of what is sometimes called 'monotonicity reasoning' ([3], [2], [13], [28]).

Case 1: from positive to positive: *Something is so if the instanced is this thing.* (*shi er ran*)("是而然")

The general feature of this case is: we get an affirmative proposition from an affirmative one. Here are some typical examples:

> A white horse is a horse. To ride a white horse is to ride a horse.
> A black horse is a horse. To ride a black horse is to ride a horse.
> Jack is a person. To love Jack is to love people. (No 14)

Reading such texts reminds us of the following sort of examples:

(1) If some dogs ran, then some animals ran.

This is a typical example of an 'upward monotonicity inference' considered in medieval Western logic, and revived in its modern variants of 'natural logic' (see [4], [8]). These inference describe the following crucial phenomenon, which is ubiquitous in practice: which statements remain true when we pass from one predicate to another one in their natural order of denotational 'extension'?

The underlying reason why the logical inference can proceed in Example (1) is twofold. First, the denotation of the predicate 'animal' is an extension of that of 'dog', while second, the existential quantifier in 'some dogs walked' creates a 'positive' or 'upward-entailing' environment for the predicate 'dog'. In Aristotle's terms, such inferential contexts allow us to move up from a species to a larger genus.

A brief summary of monotonicity inference Before continuing with this perspective on the Mohist pattern of 'parallelizing', let us review briefly the main points of monotonicity inference. There are four basic inferences based on this sort of structure, which depend on the kind of quantifier and the argument position of the relevant predicate.

Right-upward monotonic quantifiers (upward-entailing in the VP (Verb Prase), for short: 'upward-entailing'), e.g., 'some', 'most', 'almost all', 'every', 'all') – with the formal pattern

Q Fs are Gs,

The following example replaces 'ran rapidly' by the larger predicate 'ran':

(2) If some dogs ran rapidly, then some dogs ran.

Left-upward monotonic (upward-entailing in the NP (Noun Prase)), e.g. 'not every', 'some'.

The preceding example (1) "If some dogs ran, then some animals ran" illustrates this type.

Right-downward monotonic (downward-entailing in the VP, or just 'downward-entailing'), e.g. 'no', 'not every', 'at most three').

Again, we give an example:

(3) If at most two dogs ran, then at most two dogs ran in the garden.

Our fourth and final case is this:
Left-downward monotonic (downward-entailing in the NP), e.g. 'every'.

An example is the following:

(4) If at most two animals ran, then at most two dogs ran.

This is the standard account of monotonicity, where the inference applies to argument positions immediately following the main quantifier in the sentence, in the patter "Q NP VP". But of course, quantifiers can also occur in other positions, for instance, inside a noun phrase or a verb phrase. A crucial theme dating back to medieval logic, and returning in Frege's

first-order logic, is that inference can occur there as well, since inferential powers are 'inherited' into deeper sentence positions, provided we understand the construction of the sentence. ([28] has a detailed history of this issue.) Describing the right mechanisms for both 'surface' and 'deeper-level' monotonicity inferences is a crucial issue in current systems of natural logic.

With all this in mind, let us return to the Chinese texts. In the preceding spirit, the Chinese horse-riding example can now be re-written as:

- If you ride a white horse, then you ride a horse.

First, the initial sentence 'a white horse is a horse' provides the relevant extension of predicates. Next, the expression 'you ride a horse' sets up an upward-entailing inferential environment for the predicate 'horse', based on the existential quantifier "a" in the inside the VP argument. [8] Thus we can successfully apply upward monotonicity, and infer that 'you ride a horse'.

The same analysis applies to our other examples, including the one with the individual 'Jack', which we may construe as upward monotonicity triggered by a proper name, viewed as a special sort of monotonic quantifier.

Digression Mohist examples may have more than one plausible interpretation. Consider the following text:

> 'A gou is a quan, to kill a gou is to kill a quan.'(*Gou, quanye, shagou weizhi shaquan, ke.*)("狗，犬也，杀狗谓之杀犬，可。")(B 54)

We can formulate this in an analogous way:

- If you kill a gou, then you kill a quan.

As we learn from the section 2, *gou* and *quan* are different names with the same extension. We can either view this as a limiting case of monotonicity inference, replacing a predicate by another with the same extension, or as a case of Replacement of Identicals more in line with issues in intensional logic (see below). The Chinese text does not tell us enough to decide which interpretation fits better.

Next, we consider inferences involving negations.

Case 2: Negative conclusions and non-conclusions: *Something is not so, though the instanced is this thing.* (*shi er buran*)("是而不然"):

[8] A modern natural logic analysis would say that "you" and "if" are universal quantifiers with a positive, upward entailing second argument, while inside that second argument, the existential quantifier "a" creates a positive second argument X again: "If you ride a X". Combining these two features explains the total upward-entailing character of X. These details go beyond the basic connection we are trying to establish here.

These are cases where, at least prima facie, upward monotonicity inference fails – which poses a challenge for us. The reasons why monotonicity does not apply can be different, and we will try to explain them, again, in modern logical terms. Let us first read the text:

> (a) Her younger brother is a handsome man, but loving her younger brother is not loving handsome men. (b) A carriage is wood, but riding a carriage is not riding wood. (c) A boat is wood, but entering a boat is not entering wood. (d) Robbers are people, but abounding in robbers is not abounding in people, being without robbers is not being without people. (NO 15)

Consider (*a*) first. It says that she loves her younger brother, but she need not love handsome men. We do have 'Her younger brother is a handsome man', which emphasizes the inclusion of extensions. What happened to block the upward monotonicity? Here are two possible explanations. One is purely extensional, and has to do with the *quantificational force* of 'handsome men'. If we read this as universal (loving all handsome men), then there is no inclusion from 'her brother' to 'handsome men', and no monotonicity inference is justified. But if we read 'handsome men' as existential, then 'her brother' is indeed extended by the predicate 'handsome man', and a monotonicity inference would be available in principle. How could it still be blocked then?

We propose that this is an additional issue of *intensionality*. 'Love of her brother' (qua brother) is not the same as 'love of a handsome man'. This meaning shift explains why the monotonicity inference fails. The same style of thinking also explains (*b*) and (*c*). In (*b*), riding a carriage means to 'ride-qua-vehicle', whereas one does not ride 'wood-qua-vehicle'. In modern logical terms, one would accept the stated inference read in an extensional sense, but not in an intensional sense. Example (*c*) even uses a Chinese pun. The idiom 'entering wood' means 'going to die', while 'entering a boat' just means 'going into a boat'.

The fourth example (*d*) involves two further phenomena. First, the verb 'abounding' has the force of an indefinite quantifier 'many', whose interpretation depends on some standard supplied by its left-most predicate. The truth value of a sentence "Many A are B" depends on a standard supplied by the predicate A, or even further aspects of context (cf. [22]). In particular, the standard for 'abounding' in the context of the predicate 'robbers' is different from that for 'abounding' for the predicate 'people'. Thus, in addition to intensionality, the Mohist text observes quite correctly that *context dependence* can block monotonicity inferences.

The last sentence is yet different, and takes us back to our initial pure monotonicity reasoning. *Upward-* and *downward monotonic* contexts are related, and switches are possible. In particular, the word 'no' generally reverses upward contexts to downward ones. The same holds for variants of 'no', same as 'without'. For instance, 'being without people' implies 'being without robbers', where robbers is a sub-predicate of people. The final sentence in (d) reflects this: 'robbers' now occurs in downward monotonic position, and hence no upward predicate replacement is allowed. Of course, 'being without robbers' now does imply 'being without Chinese robbers'. While such downward consequences occur explicitly in medieval Western logic, and in modern natural logic, they seem absent from the Mohist texts.

Finally, here is a third scenario from the Mohist canons. We can also get an affirmative proposition without an inclusion condition.

Case 3: Positive conclusions not based on inclusions : *Something is so though the instanced is not this thing.*(*bushi er ran*)("不是而然")
Again, here are some typical examples with a formal flavour:

> (a) Reading a book is not a book, but to like reading books is to like books. (b) A cockfight is not a cock, but to like cockfights is to like cocks. (c) Being about to fall into a well is not falling into a well, but to stop someone from being about to fall into a well is to stop him from falling into the well. (NO 16)

(*a*) says that, if you like reading books, then you must like books. This looks like upward monotonicity, and indeed, the pattern is like that of an earlier example, with an upward occurrence of X in "If you like reading books, then you like X". Still, Case 3 does not supply an inclusion allowing us to exploit this, and in fact, it denies an inclusion! What is going on? It seems that the Mohist inference is rather after something else here, viz. the notion of *presupposition* – like when we conclude from 'My wife is pregnant' that the speaker has a wife. More concretely here, 'reading books' presupposes 'being involved with books', and this does supply a basis for a monotonicity inference. "If you like reading books, then you like X", "Reading books implies being involved with books", and hence "If you like reading books, then you like (being involved with) books". The same explanation may be given for (*b*). [9]. Finally, example (*c*) is still different, but also not hard to

[9] The first part of (a) and (b) seems strange: we know that reading a book is definitely not a book itself, but people rarely say it that way in natural language. But the logical point of the text is that, despite this negative fact, there is a valid inference, even though it is not a simple replacement.

understand when we use presuppositions of 'being about to' plus the tenses that are involved.

Let us be clear on what we have done here. The Mohist texts give certain system of classifying positive and negative inferences. We have proposed an interpretation in terms of monotonicity inference, which fits a number of these cases. But this was not the whole story, because we needed to bring in several further considerations. Sometimes, the necessary inclusion premise is not supplied by general predicate extension in some categorical sense, but by presupposition. And also, pure monotonicity inference can be affected by more delicate features of predication in natural language, viz. its context dependence, and the phenomenon of intensionality of meanings.

At this stage, we want to emphasize a disclaimer. Our claim in the logical analyses of this section is by no means that the Mohist texts contain a systematic theory of logic in a modern, or even a classical Aristotelian, sense. They contain examples, and behind the examples, one can indeed sense a systematization. But since the latter remains largely implicit, one has to reconstruct it, beyond what is explicit in the text. Even so, we feel that the above discussion does show that the Mohists were after typical 'logical' inference patterns, and we propose our interpretation at least as a new way of reading old texts, which may help us see more structure to what Mohist logicians were after.

This concludes our brief survey and explanation of key reasoning patterns in the Mohist Canons. To us, the analogies in form and spirit to Western logical themes are quite striking and we feel that our analysis has not 'twisted' the intent of the original beyond recognition. In fact, our case could even be strengthened, since further propositional kinds of reasoning were considered as well, based on the earlier-mentioned account of disjunctions and conditionals. We will leave these to another occasion.

5 Disputation

Next, inferences, valid or not, do not occur in isolation: they form part of larger human activities. Just as in Ancient Greece or Rome, disputation was popular among various Schools of thought during the Warring States period. They criticized each other and tried to convince their King with their new proposals. The Mohists were not only concerned with the practice of disputation, but also with its meta-theory. We can find many illuminating discussions of this topic in the Canons. For instance, here is how they define a disputation: "disputation means contending over claims which are the contradictory of one another" (*bian, zhengbi ye.*)("辩，争彼也。")(A 74). To show what such contradictory claims are, one example given is: "One

calling it 'ox'(P) and the other 'non-ox'($\neg P$) is contending over claims which are contradictories of each other" (*weizhiniu, huo weizhifeiniu, shi zhengbi ye.*) ("谓之牛，或谓之非牛，是争彼也。")(A 74).

Furthermore, the Mohist Canons propose basic principles regulating disputations. The first says that of two contradictory propositions, one must be false, they cannot be true at the same time. (*shi bujudang, bujudang bi huo budang*) (是不俱当，不俱当必或不当。)(A 74). This is exactly what the logical Law of Non-Contradiction means! Secondly, the texts say that two contradictory propositions cannot be both false, one of them must be true. (*weibian wusheng, bi budang, shuo zai bian*)(谓辩无胜，必不当，说在辩。)(B 35). This, of course, is the Law of Excluded Middle. There seems to be a consensus nowadays that the Mohists explicitly proposed two basic logical laws, but cf. the earlier controversial discussion in [17]. Still, what is interesting to point out is that the discourse function of logical laws, instead of their theoretical function, is more emphasized by the Mohists.

What is more, the Mohists also talked about the broader purpose of disputation in general. We would like to conclude this section by citing their comprehensive and yet highly concise description in the following text:

> The purpose of disputation is (1) by clarifying the portions of 'is-this' and 'is-not', to inquire into the principle of order and misrule; (2) by clarifying points of sameness and difference, to discern the patterns of names and of objects; (3) by settling the beneficial and the harmful, to resolve confusions and doubts. Only after that, one may by description summarize what is so of the myriad things, and by asserting seek out comparables in the multitude of sayings. (NO 6)(HC 6A/9-6B/1)

Passages like this from the founding period of logic are intriguing, as modern logicians are becoming more interested in regaining argumentative multi-agent perspectives on logic, in addition to the dominant paradigm of reasoning as single-agent mathematical proof ([5], [15], [24]).

6 Paradoxes

Finally, we mention one more striking analogy between Mohist Logic and its counterparts elsewhere in the world, in the form of two illustrations.

Many *paradoxes* are discussed in the Canons – and these, of course, almost seem a hallmark of the profession of logic. This interest in paradoxes may lie in its direct connection to the earlier central concern with disputations, where one has to avoid being self-contradictory. Let us start with the first example, which is stated in (B 71):

> To claim that all saying contradicts itself is self-contradictory. Explained by: what he says himself.
>
> (*yi yan wei jinbei, bei. shuo zai qiyan.*)(以言为尽悖，悖。说在其言。).

Here is the implicit argument. Assume that we accept 'all saying contradicts', then the sentence 'all saying contradicts' is false itself. What this means is some statements are not contradictions. Thus, the Mohists were aware of the phenomenon of self-reference, and its remarkable logical consequence of self-refuting statements. Clearly, this example is close to the paradox ascribed to the Cretan philosopher Epimenides in the sixth century B.C., who asserted that "Cretans are always liars." While this is not quite the famous Liar Paradox, which is contradictory whichever way one looks at it, it comes close.

We conclude with a second Mohist paradox, which seems original without an obvious Western counterpart. It says:

> That it is useful to learn. Explained by: the objector.
>
> (*xuezhiyi ye, shuo zai feizhe.*)(学之益也，说在诽者。)(B 77)

The underlying argument goes like this. Thinking that someone does not know that it is useless to learn, you therefore inform him. This is causing him to know that it is useless to learn. But if it is really useless to learn, to teach (making people learn things) is to contradict oneself. This paradox seems to involve pragmatics of speech acts. Even so, its typical use of self-reference will sound highly congenial to Western logicians.

We will leave a more detailed exploration of further Mohist paradoxes to other occasions. As we know from history, far from being isolated puzzles, paradoxes have contributed immensely to the development of logic. In this respect, again, the Mohist logicians were on to something crucial, at the same time as their counterparts worldwide.

7 Conclusion

From the standpoint of modern logic, and taking a comparative perspective, we have given a survey of some major themes in Mohist Logic. In particular, we have argued for the following specific conclusions:

- Variables were used by the Mohists, and even earlier by the Sophists.
- The Mohists had the idea of logical constants, distinguishing these from non-logical expressions in natural language.
- They had systematic abstract reflections on reasoning and some of its central valid and invalid patterns, including inferences based on monotonicity, as well as various factors blocking this.

• The Law of Non-Contradiction and the Law of Excluded Middle were proposed as central to driving the process of disputation.
• They made original contributions to the study of logical paradoxes.

Our work is only a first step, and much further systematic study is needed. But even so, we hope to have given our readers a rough picture of the Mohist Canons, and hence of logical activity in China around 500 B.C., from a modern point of view.

Living in Ancient China over two thousands years ago, the Mohists may have had no idea what was going on in Ancient Greece, Rome, or even India.[10] However that may be, nowadays we are often amazed by the similarity of great ideas and great minds across cultures. Unfortunately, the two stories have gone very differently as one travels toward modern history. Although the Mohists provided an option of making reasoning and disputation the core of intellectual inquiry, their doctrine did not survive in Chinese history and philosophy. As we know, after the first unified dynasty Qin was founded, Confucianism became the dominant doctrine, which has lasted throughout Chinese history. In contrast to this, in the West, no lasting political unification took place, and in line with this diversity, the Western philosophical tradition has remained diverse, adopting and developing the rationalistic dialogical approaches of Plato and Aristotle. This historical observation may provide some explanation of the differences between Chinese and Western culture as we see them today.

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[10] But as historians remind us, one should never underestimate what Ancient people already knew about the world at large through trade and other contacts.

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