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Introductory Remark

This preprint contains two contributions, *Mechanics in the Mohist Canon: Preliminary Textual Questions* by William G. Boltz (p. 1) and *Mechanics in the Mohist Canon and Its European Counterpart* by Jürgen Renn and Matthias Schemmel (p. 14). The contributions are based on talks given at the *3rd International Symposium on Ancient Chinese Books and Records of Science and Technology* held in Tuebingen from March 31 to April 3, 2003. They will appear in the proceedings of this conference, *Study on Ancient Chinese Books and Records of Science and Technology*, Elephant Press, Zhengzhou, China.

Mechanics in the Mohist Canon and Its European Counterpart

Jürgen Renn and Matthias Schemmel

What to Compare?

This paper is concerned with the sections of the *Mohist Canon* 墨經, dating from about 300 B.C., that have traditionally been classified as concerning mechanics. Given the fact that the term mechanics usually refers to a branch of knowledge in the Western scientific tradition, the classification of the Mohist sections as concerning mechanics immediately raises the question of their comparability to anything occurring in the history of Western science. In fact, such comparisons have been made. Joseph Needham, for example, concluded his analysis of one of the Mohist sections with the following assessment:[1]

> The most important thing about this excerpt on the lever and balance is that it shows that the Mohists must have been essentially in possession of the whole theory of equilibria as stated by Archimedes.

However, on closer inspection, the comparison of the *Mohist Canon* with Archimedes' book on the equilibrium of planes turns out to be problematic. A crucial aspect of Archimedes' work is that it is deductively structured. It is, in fact, this aspect which is often taken as one of the main reasons for judging it a scientific work. The *Mohist Canon*, in contrast, is not structured in this way. A further crucial aspect of Archimedes' work is that it contains and even proves the law of the lever—the first law of mechanics in the history of Western science. The Mohist text again does not contain a formulation of this law, let alone its mathematical proof in the Western sense.

1 Joseph Needham *Science and Civilisation in China Vol. IV: Physics and Physical Technology Part 1: Physics*, Cambridge: Cambridge University Press, 1962, p. 23.

While it thus appears that there is little justification to compare the mechanical sections in the *Mohist Canon* to Archimedes' theory on the equilibrium of planes, the question remains whether any parallel exists between the independent traditions of mechanics in China and the West. In order to answer this question, one has to start by re-examining the Mohist sections on mechanics. Based on the thorough philological reconstruction of the *Mohist Canon* by A. C. Graham,[2] a detailed re-examination has been jointly undertaken by a working group at the Max Planck Institute for the History of Science in Berlin and by William Boltz at the University of Washington in Seattle.

On the background of Graham's work, two features of the *Mohist Canon* have emerged as being particularly striking:

- A basic structure of reasoning is common to all sections. It is characterized by treating mechanical problems as puzzles and is reflected by a coherent use of technical terms for mechanical qualities, such as *zhong* 重 for "weight" or *quan* 權 for "positional advantage," as Graham's translation reads. (On the basis of our analysis we have proposed the latter term to be translated as "effectiveness," see below.) This basic structure of reasoning is quite independent of any specific interpretation of the sometimes obscure passages.
- That structure of reasoning is largely shaped by the role of the text in representing knowledge in a culture of dispute, characteristic of the Chinese philosophical practice of the time.[3]

These features suggest comparing the mechanical sections in the *Mohist Canon* not to Archimedes' writings on the equilibrium of planes to which Needham is referring but rather to another ancient text documenting the emergence of a science of mechanics in Europe. This is the so-called *Mechanical Problems* ascribed to Aristotle and his school. The text was written in about the same period as the *Mohist Canon* and represents the earliest European text on mechanics handed down to us. In contrast to Archimedes' work, *Mechanical Problems* is not deductively structured and does not, in its original form, contain the law of the lever, or at least does not ascribe any central status to it. On the other hand, the text possesses the features just ascribed to the *Mohist Canon*: it also treats mechanical problems as puzzles and is shaped by a

2 Angus Charles Graham *Later Mohist Logic, Ethics and Science*, Hong Kong: Chinese University Press, 1978.

3 See, in particular, William Boltz' contribution to this preprint.

coherent structure of argumentation. This structure is reflected by the use of technical terminology, and has its origins in a culture of dispute characteristic of the Western philosophical tradition of the time.

In this paper we address the question of whether this parallel between the mechanical sections in the *Mohist Canon* and *Mechanical Problems* merely concerns the formal structure of the two texts, or whether it also extends to their substance, namely the kind of knowledge on mechanics they embody. As will become clear in the following, such a question cannot be approached by purely philological means. Rather, one has to take into account that there are different kinds of shared knowledge underlying scientific reasoning. We systematically distinguish three kinds of knowledge. These are intuitive, practical, and theoretical knowledge, which are distinct with regard to their sources, to their modes of transmission, and to their inner structure. Intuitive knowledge is acquired in the process of ontogenesis. Since the physical conditions of ontogenesis are largely culture-independent, a great part of this knowledge may be considered universal. Another kind of knowledge may be termed practical knowledge. This is expert knowledge acquired in the handling of artefacts such as mechanical instruments, devices, and machines, and is therefore as culture-dependent and subject to historical change as these artefacts are. For example, the knowledge acquired when using a lever can be termed practical knowledge. Finally the third kind of knowledge may be called theoretical knowledge. Theoretical knowledge is characterized by the use of symbolic representations as provided by written language, giving rise to a drive for consistency and the emergence of abstract terms. All three kinds of knowledge are structured by mental models.[4] For instance, according to a typical model of intuitive physics, the greater a force, the larger its effect. The model also figures in the knowledge of practitioners who experience this relation of force and effect when handling their instruments. Finally, the model may be a part of theoretical knowledge, as is the case in Aristotelian physics, where it amounts to a theoretical statement of universal validity.

In the following we give a brief account on how the knowledge on mechanics embodied in the two texts, the sections on mechanics in the *Mohist Canon* and in *Mechanical Questions*, can be analysed and compared within the theoretical framework outlined above.

4 For the notion of mental model and its application in describing historical forms of thinking, see Dedre Gentner and Albert L. Stevens (eds.) *Mental Models*, Hillsdale: Erlbaum, 1983.

The European Case

Mechanical Problems is the earliest surviving text on mechanics in the Western tradition. It was influential in this tradition until the advent of classical mechanics in the age of Galileo and Newton. The text consists of an introduction and 35 sections called "problems," which are often merely one paragraph in length and almost always begin with the phrase "Why is it that … ?" The first three sections are theoretical in character and introduce basic concepts and principles, indicating their connections to one another. Several of the subsequent problems apply these principles to provide an explanation for a number of phenomena resulting from the use of devices that allow, as the author writes, the weaker to master the stronger. His entire enterprise starts from the question:[5]

> Why is it that small powers [can] move big loads when using the lever?

In discussing various mechanical devices, the author attempts to reduce them to the lever, which in turn is reduced to the balance with unequal arms, functioning according to the general principle:[6]

> The further that which moves the load is away from the fulcrum, the more it moves the load.

This pattern of argument, also recognizable in the text due to the consistent technical terminology associated with it, in fact relates the transformation of forces by mechanical devices to experiences which can be gained by varying the lengths of the arms of unequal-armed balances.

While *Mechanical Problems* thus reflects the basic knowledge of practitioners, the text is clearly not motivated by practical concerns. The literary form of *Mechanical Problems* reflects the Greek *problemata* tradition which probably emerged from a real dialogical situation.[7] Obviously, the topic of mechanical instruments was addressed by its author merely because they constituted a provocation to the Aristotelian system of natural philosophy. While *Mechanical Problems* was thus a rather marginal component of the corpus of writings of Aristotle and his school, in hindsight one may nevertheless perceive in it the origin of theoretical mechanics.

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5 *Mechanical Problems*, Problem 3.

6 *Mechanical Problems*, Problem 4.

7 On the tradition of *problemata* see, for example, Hellmut Flashar [ed.] *Aristoteles Werke in deutscher Übersetzung, Vol. 2: Problemata physica*, Berlin: Akademie Verlag, 1991, pp. 297–303.

In our interpretation of *Mechanical Problems*, then, the text addresses the challenges to Aristotelian physics that are presented by technical devices which produce beneficial effects that seem contrary to nature. As mentioned in the beginning, the mental model implying that a greater force produces a greater effect had, in the context of Aristotelian physics, turned into a universal statement. The text responded to the puzzles raised by mechanical devices producing effects which appeared to contradict this model. It did so by extending this model to a model which was itself based on practical experience attained by using unequal-armed balances that had only recently become commonplace in Greece. In the case of this kind of balance, the effect of a weight depends on the weight's position on the beam. The model of the balance and its theoretical justification could therefore become a general scheme accounting for the unexpected behavior produced by various devices of ancient mechanical technology.

The Chinese Case

We now turn to the earliest text on mechanics from the Chinese tradition, again beginning with a short recapitulation of its essential features. What we call a "section" of the *Mohist Canon* is made up from a *Canon* in the proper sense and an *Explanation* co-ordinated with it. The basic structure of the *Mohist Canon* as reconstructed by Graham[8] is twofold (see the table below). The sections of the *Mohist Canon* cover "four branches of knowledge." The first one may be called logic, though it is not a logic of syllogisms, but rather a reflection on language offering procedures for consistent description in order to avoid paradoxes. The second is on ethics and the last on the art of disputation. Of interest here is the third branch that may be referred to as being concerned with science (printed in bold face in the table below), and in which the sections on mechanics are found. Each branch of knowledge is dealt with in two parts. In one part certain basic terms are defined, in the other place complex problems are dealt with.

8 See Graham *op.cit.* pp. 30–2, 229–35.

Structure of the Mohist Canon

The four branches of knowledge	*Definitions*	*Propositions*
1. Explaining how to relate names to objects	"Reason," "unit," "knowing"	Procedures for consistent description
2. Explaining how to act	Conduct and government	(Expounding the Canons)
(Bridging part: knowledge and change)	Spatial and temporal conditions of knowing	Spatial and temporal conditions of knowing
3. Explaining objects	**Geometry**	**Problems in optics, mechanics, and economics**
4. Explaining words	disputation (bian)	Problems in disputation

The section on which Needham bases his far-reaching claim mentioned above has been only partially preserved. The first phrase of the *Explanation* reads:[9]

> （衡。）加**重**於其一旁必捶，**權重**相若也。
>
> (The beam.) If you add a **weight** to its [i.e. the beam's] one side [this side] will necessarily hang down. This is due to the **effectiveness [of the weight]** and the **weight** matching each other.

The passage may be illustrated by imagining a practical situation in which a beam is suspended with the help of a noose in such a way that the noose can be moved along the beam's length. If a weight is attached to one side of the beam then this side will hang down. Here, the term "weight" (*zhong* 重) is complimented with another term, the *quan* 權 . In the *Mohist Canon* we understand this term as designating an abstract measure of the effect the weight has. In the case at hand, the weight and its effectiveness (*quan* 權) match each other, i.e. the effect of the weight is as expected: the side where the weight is placed goes down. So far, this is in accord with our expectations and would not have required the introduction of a technical term. Now, however, as the explanation continues, things get more involved:[10]

> 相衡，則本短標長。兩加焉**重**相若，則摽（＝標）必下，標得**權**也。
>
> Level [both sides] up with each other, then the base is short and the tip is long. Add equal **weights** to both sides, then the tip will necessarily go down. This is due to the tip having *gained* **effectiveness [of the weight]**.

9 Section B 25b. Here and in the following quotation we mark the technical terms for mechanical qualities in bold face.

10 Section B 25b.

Now the beam with the weight attached to one of its sides is brought into the horizontal position again. To achieve this, the fulcrum, i.e. the point of suspension, has to be moved. The result is that one side of the beam, when counted from the fulcrum, is shorter than the other. The Mohist calls the side having the weight attached to it the "base" (*ben* 本), which is now short, and the other side the "tip" (*biao* 標), which is now long. After adding equal weights to both sides of the beam, something unexpected can be observed. While intuitively it seems to be clear that equal weights cause equal effects, the tip can now be observed to decline. This is what one would expect if the weight laid on the side of the tip were greater than that laid on the side of the base. It thus seems that the weight on the "tip"-side is somehow more effective than that on the "base"-side. This is expressed by the statement that the tip has gained in effectiveness. Most probably, the lost canon referred to this phenomenon which forced the Mohist to introduce the technical term, "effectiveness."

The central question addressed by this passage is as follows: how can it be that one and the same heavy body has, under certain circumstances, a different effect from the one it normally has? It is answered by introducing a pair of abstract terms, weight and effectiveness, that differentiate the term weight in order to account for its different behavior under certain circumstances.

From this reconstruction it becomes clear that the essential feature of the above passage, a feature that it shares with other mechanical sections, is the confrontation of the natural behavior of an object with the modified behavior it displays under certain artificial circumstances. The mechanical arrangements producing these circumstances can sometimes be reconstructed, as is the case for the section just discussed, while they remain obscure in other sections. In any case, their significance lies in their interference with the naturally expected course of things, which yields a puzzling outcome. We thus encounter a beam that does not bend although it is burdened with a weight, a curtain that comes down by itself although it has first to be pulled up with an effort, or something that leans and cannot be set upright. The natural tendency of a weight would be to move down vertically by itself. But the interference with an artifice, such as pulling a weight up or to the side or supporting it from below, prevents this from happening in the contrived circumstances introduced in the text. This general feature of the argumentation is expressed in the text itself by the following statement:[11]

11 Section B 27.

凡重，上弗挈，下弗收，旁弗劫，則下直。*施，或害之也。

Speaking generally about weight, when you are not pulling it up, and when you are not letting it down, and when you are not pulling it to the side, it comes straight down. When it comes down on a slant this is because something is interfering with it.

In the course of the argument, the Mohist introduces a number of technical terms for mechanical qualities. There are, for example, terms for letting a weight down, for suspending it from above, or for pushing it from the side. Some of the technical terms are used in order to account for the non-natural behavior described above. In the case of the beam, which we have discussed, the "effectiveness of the weight" (*quan* 權) is such a term. Another such term is the "degree of fixed rigidity" (*ji* 極) as William Boltz explains in more detail in his contribution to these proceedings.

As was the case for the Aristotelian *Mechanical Questions*, the argumentative structure that has become clear from the preceding interpretation can be understood as resulting from a reflection on shared practical knowledge in the context of a culture of disputation. The artifices occurring in the mechanical sections represent mechanical devices that evidently played a role in contemporary technology, for example, in the techniques of military engineering in which the Mohists are believed to have excelled. While the knowledge documented by their texts thus has a practical background, the issues they raise are clearly not practical problems but a matter of theoretical reflection, drawing on the means offered by contemporary philosophical discussion. Following Graham's argument,[12] the Mohists opposed the derivation of ethics from natural tendencies, as was advocated by the Confucian tradition in reaction to the so-called Individualists, in particular Yang Zhu 楊朱. They rather strove to demonstrate that ethics could consistently be grounded in the sphere of human intentions and actions. In a similar way, the Mohists' occupation with mechanical problems appears to have been motivated by the philosophical concern to show that, while mechanical processes induced by man may not occur as intuitively expected, they still remain rationally comprehensible.

On the basis of the mental model of intuitive physics representing the idea that a greater force has a greater effect, the structure of the mechanical sections may then be understood as follows. The model implies that equal weights have an equal effect. The practical experience gained in

12 See Graham *op.cit.* pp. 15–25.

handling mechanical devices violates this model, for example, when equal weights laid on a beam have different effects. The Mohists' theoretical reflection consolidates this conflict between practical knowledge about mechanical processes and intuitive knowledge about what would naturally occur by differentiating what should be considered a cause of the effect, thus enriching and thereby restoring the original mental model.

The Parallel Origins of Chinese and European Mechanics

In conclusion, let us come back to our original question: Does the structural parallel between the mechanical sections in the *Mohist Canon* and *Mechanical Problems* extend to the kind of knowledge on mechanics that is embodied in the texts?

We have argued here that this is indeed the case: Both texts were the result of a theoretical reflection on practical knowledge, induced in the context of specific cultures of disputation. The practical knowledge, which constituted the empirical basis of the texts, was in turn transformed by theoretical reflection. One consequence of this reflection was the drive for a consistency of reasoning atypical for intuitive or even practical knowledge and, as a result, the universality of the resulting argumentation.

In China as well as in Europe, neither the existence of a culture of disputation nor its specific concerns had, in the first place, anything to do with practical mechanical knowledge. In this sense, the emergence of theoretical knowledge on mechanics was a contingent historical event that was dependent on specific cultural circumstances. As it turned out, however, the similar discursive practices in both cultures shaped the reflection on practical mechanical knowledge in a similar albeit non-identical way. It resulted in fact in such different abstract concepts as the concept of "center of gravity" in the European tradition and the concepts of "effectiveness of weight" or "degree of fixed rigidity" in the Chinese tradition.

The specific character of theoretical mechanics at its origin was as transient as the historical context that brought it about. What remained as the substance of scientific mechanics in the long run was not a specific literary form shaped by this context but rather, first of all, the mental models of intuitive and practical knowledge that remained stable over long periods of time due

to the continuity of craftsmanship and engineering, and second, the mental models of theoretical knowledge and the abstract concepts associated with them, at least as long as they were handed down in a theoretical tradition dependant on the transmission of written texts. A continuous practical tradition existed in the Chinese as well as in the European case. But while, according to our interpretation, a theoretical mechanics emerged on this basis independently both in Europe and in China, it is the continuity of the theoretical tradition that was interrupted at a very early stage in China. Evidently, the conditions for the genesis of a scientific tradition are different from those for its long-term survival.

Mechanics in the Mohist Canon: Preliminary Textual Questions

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I. Introduction : Prerequisites for comparisons.

To pursue the Chinese side of a comparative question such as "to what extent does the Mohist Canon show a development parallel to that of the Western understanding of mechanics as seen in the 'Mechanical Questions' of Aristotle," it is necessary to scrutinize the pertinent "mechanics" parts of the *Mohtzyy* within the context of the whole of what the late A.C. Graham called the Later Mohist *summa*. Before this can be meaningfully done we must give some attention to the question of what it means to undertake this kind of cross-cultural comparison in general. What kinds of things are usefully compared? What kinds of comparisons give useful or meaningful results?

Jürgen Renn in his Introduction to the recently published volume called *Galileo in Context*, emphasizes that a full and accurate appreciation of Galileo's work can only emerge from "re-examining the traditional epistemological understanding of the cognitive core of the [contemporaneous] scientific enterprise." The "Galileo myth will continue to haunt scholarship," he says, unless, instead of looking for "supposedly decisive factors" in Galileo's own life and scientific pursuits, scholars "take Galileo as a [kind of] probe for exploring a *cultural system of knowledge*," that is, in other words, exploring "the shared knowledge of the time, together with its social structures of transmission and dissemination, its material representations, and its cognitive organization." It is this phenomenon of 'shared knowledge', *i.e.*, the scientific, artistic and institutional matrix in which Galileo fits, that constitutes what Professor Renn means by the word 'context' in the title *Galileo in Context*. It is not sufficient, he points out, simply to identify "influences" or "conditions" on Galileo's thinking and actions.[1] The implication for us is, to paraphrase Jürgen Renn's comments about Galileo further, that a correct understanding of Mohist mechanics will necessarily entail a "re-examination of the traditional epistemological understanding of the cognitive core" of the Mohist scientific and intellectual enterprise and a re-consideration of the textual and intellectual context in which this part of the *Mohtzyy* appears, that goes beyond merely identifying "links" to other names or "influences" seen in other texts.

The comparative dimension of this project must also include a general assessment of what it means to undertake cross-cultural comparisons overall. This issue has been

taken up recently by Nathan Sivin and Geoffrey Lloyd in their jointly authored book, *The Way and the Word*.[2] In proposing an answer to the question "What is Comparable?" early in their discussion, Sivin and Lloyd say: "The most fruitful comparisons begin not with individual concepts or methods but with complexes of thought and activity seen in their original circumstances."[3] They tend to avoid the word 'context' in reference to what they have called "complexes of thought and activity. . ." averring that "[c]ontext is not an autonomous setting that may or may not be connected to inquiry. Technical work and its circumstances are parts of one thing. . ." This 'one thing' they call a 'manifold' and this is what they take as the basis of their comparative endeavours.[4] While for Sivin and Lloyd the word 'context' may be, at least in its naked, unqualified sense, a kind of red flag, the sense they assign to 'manifold' is not far removed, I think, from the 'context' that Jürgen Renn means in his "Galileo-in-context" view. In both cases the point is that meaningful comparison must recognize the cognitive, artistic and institutional schemes in the aggregate as inseparable from the specific focus of the comparison.

For the study of those parts of the later Mohist texts that deal with mechanics, as a starting point for a comparative study of the historical knowledge of mechanics in, respectively, China and the West, this means that we must begin by trying to ascertain what was the "complex of thought and activity" of which the Mohist mechanics was a single, very distinctive part; what, in other words, were the circumstances that reveal what it was that the Mohists thought they were doing? What did the Mohists see themselves as trying to do in setting out what look to us like descriptions or explanations of kinds of mechanical knowledge? The first place to look for answers to these kinds of questions is to the texts themselves. And in doing this, one cannot but tend carefully to the details.

II. The Later Mohist texts.

The so-called "later Mohist texts" comprise sections 40 through 45 of the received text of the *Mohtzyy*: 40 and 41 are the *jing* 經, *shanq* 上 and *shiah* 下 respectively; these are what A.C. Graham has called the 'Canons' (abbr. C); 42 and 43 are the *jing shuo* 經說, also *shanq* and *shiah* respectively, called by Graham the 'Explanations' (abbr. E); and 44 and 45 are the *dah cheu* 大取 and *sheau cheu* 小取 respectively, the 'Greater Pick' and the 'Lesser Pick'.

It is well-known that these sections of the *Mohtzyy* are among the most difficult parts of the whole work. This is generally attributed to the fact that they seem to have suffered a considerably greater measure of textual corruption in the course of their transmission than most other parts. By the same token, and reasoning somewhat circularly,

it is similarly claimed that it is precisely the inherent difficulty of these parts that has led to this greater measure of textual corruption, the reasoning being that texts that are intrinsically hard to understand are more vulnerable to miscopying or to deliberate, if misguided, efforts at elucidation through emendation than are texts the meaning of which is generally clear. Whatever the causes of the perceived textual corruption, the textual problems of the later Mohist documents fall clearly into two types: (i) structural and (ii) orthographic. By 'structural' I mean the misplacement or disorder of lines and paragraphs relative to one another, and by 'orthographic' I mean simply the occurrence of unfamiliar and otherwise unattested graphs and puzzling character variants. The former is properly described as textual corruption, having arisen over the course of the text's transmission; the latter, unlike the problem of structural corruption, is for most of the Later Mohist texts not a reflection of corruption at all, but is, somewhat ironically, probably a consequence of extreme orthographic conservatism, to be attributed in large part to the *absence* of editorial emendation over time. The *Mohtzyy* text seems to have lain more or less untouched by editorial or commentarial attention for more than a millennium after the Han period, and many unusual character forms that were in other texts replaced through processes of orthographic conventionalization and standardization remain unchanged in the *Mohtzyy* and now appear anomalous relative to the standard orthography of the received writing system. The challenge in the first case is to determine what the correct, intended order of the lines or phrases should be, and in the second to determine what word is intended by the character that appears in the text. As Graham has shown, both of these features of the text present formidable problems, but neither makes the task of understanding these texts hopeless.

III. The Later Mohist *summa*, *jing* 經 and *jing shuo* 經說:

Let me first give the opening passage from the mechanics section of the text as an example to illustrate the nature of the *jing* and *jing shuo* sections:

B 25a: C: (貞 >) 負而不橈，說在勝。

E: (負。) 衡木(如 >) 加重焉而不橈，極勝重也。右校 (=絞)交繩，無加焉而橈，極不勝重也。

Canon: When something bears a load but does not bend, the explanation lies in its 'capacity for prevailing'.

Explanation: [Load-bearing.] When a horizontal beam, having had a weight added to it, does not bend, this is due to the 'degree of fixed rigidity' prevailing over the weight. When a twined-cord twisted to the right, with

nothing added to it, bends; this is due to to the 'degree of fixed rigidity' not prevailing over the weight.

The character *jen* 貞 in parentheses is what the received text has here, and the arrowhead followed outside the parentheses by the character 負 for *fuh* 'to bear' indicates the proposed emendation. (Emendations based on this kind of graphic confusion are always so indicated.) What I have called in the translation here 'degree of fixed rigidity' is the word *jyi* 極, which Matthias Schemmel and I had earlier translated as 'pole-quality' and which Graham renders as '(being at) full stretch'. While both of these alternative translations make sense in this instance, to be sure, they both miss the consistency of the usage here with the usage of *jyi* in other parts of the *Mohtzyy*, *e.g.*, in sections 39 and 48 ("Fei Ru" 非儒 and "Gong Menq" 公孟 respectively) where the word occurs in a sense parallel to *minq* 命 'fated, predestined'; *i.e.*, meaning 'fixed, unalterable, determined', and where neither our earlier 'pole-quality' nor Graham's 'being at full stretch' works very well:

> Sec. 39: 強執有命以說議曰壽夭貧富，安危治亂，固有天命。不可損益。窮達，賞罰，幸否，有極。人之知力不能爲焉。
>
> [The Ruists] tenaciously maintain a [doctrine of] "Fated", on the basis of which they argue "whether one lives a long life or short, in poverty or in wealth; whether things are stable or imperiled, well-ordered or in chaos, assuredly these all are celestially 'fated' and cannot be reduced or increased. Whether one fails or succeeds, is rewarded or punished, fortunate or not, these things are **rigidly fixed** and neither a person's knowledge or efforts can have any effect on them."
>
> Sec. 48: 又以命爲有。貧富壽夭，治亂安危，有極矣。不可損益也。
>
> [The Ruists] take 'Fate' as a given. Whether one is rich or poor, lives long or dies young; whether things are well-ordered or in chaos, stable or imperiled, there is a measure of **fixedness** to them and they cannot be reduced or increased.

The sense of *jyi* in the mechanics passage has to be seen as quantitatively relative since in its second occurrence, that of the twisted cord, there is in fact very little or no 'fixed rigidity' at play and yet the term still is used substantively, so we have to understand it as a matter of degree. If we admit a presumption of lexical consistency between the mechanics section of the *Mohtzyy* and the rest of the text, including the "Fei Ru" and "Gong Menq" sections, then we will have to see that the use of *jyi* there, too, parallel to

minq 'fated', must also be relative, *i.e.*, must allow for a degree or measure of 'fixed-rigidity' other than absolute.

By the same token, notice that the final occurrence of the word *jonq* 重 'weight' in B 25a must be understood abstractly as an intrinsic quality of the twined-cord itself, and not just as a reference to an external object such as was described in the preceding sentence as something added to the beam. The meaning of *jonq* in this case is what we might call the inherent 'weightiness' or 'gravity' of the twined-cord, a quality that the cord has by virtue of nothing more than being that object. This too matches the everyday use of the word *jonq* 重 'weight' elsewhere in the *Mohtzyy*, *e.g.*, in sections 28 and 01 ("Tian jyh", *shiah* 天志下 and "Chin shyh" 親士 respectively):

> Sec. 28: 吾以此知天之重且貴於天子也。
>
> In this way I recognize the **gravity** and merit alike of Heaven to be greater than those of the Son of Heaven. (*i.e.*, . . . I recognize that Heaven is 'weightier' and more meritorious than the Son of Heaven.)
>
> Sec. 01: 良馬難乘，然可以任重致遠。
>
> A fine horse may be difficult to mount, but even so can bear **burdens** to great distances.

In section 01 the sense is concrete, a 'weight' as an external object imposed on something, but in section 28 the sense is abstract, the 'weightiness' or 'gravity', as I have called it, inherent to a thing itself. Both of these senses and usages are common in normal Classical Chinese, and both of them figure precisely in the terminology of the B 25a mechanics passage cited here.

Overlooking this kind of lexical consistency would obscure the fact that usages in the Later Mohist texts, even when appearing to be in some sense "technical," are not fundamentally different from expected uses of the same words elsewhere in the *Mohtzyy* and that the meaning in one place may throw some light on how the word is to be understood in another place. Still more fundamentally, recognizing these kinds of shared lexical links is one way to establish the intellectual or rhetorical context of which the Later Mohist texts, in particular the mechanics sections, are a part. This same observation applies *mutatis mutandis* to grammatical features. Graham himself, as one of his most general assertions about the whole Later Mohist *summa*, said that these texts are fundamentally a part of a body of written materials in the tradition of disputation and argumentation. He regards them as markedly more sophisticated in their style and content than the earlier Mohist texts, but nevertheless in the same disputational tradition

as, *e.g.*, the treatises against aggression (sections 17-19, "Fei gong" 非攻), in favor of societal and institutional conformity (sections 11-13, "Shang torng" 尚同), promoting an ethic of comprehensive caring for one another (sections 14-16, "Jian ay" 兼愛), *etc*., all of which are explicitly, often bluntly, argumentative.

The Later Mohist texts are, according to Graham, not intended as objective, scientific descriptions or accounts of anything, but rather are a particular part of a codification of what is regarded as knowledge, how things can be reliably known, and how such an understanding determines actions. This in turn is intended to serve as a basis for defending Mohist tenets in debate.[5] The goal ultimately seems to be to establish a kind of implicit procedure for evaluating competing claims about social and political behaviour. In this respect we can expect these texts to be conceptually and logically precise and rigorous, but at the same time we must see them as contributing to an overall scheme of polemics, not as neutral accounts of perceived experience, and this makes their descriptions and explanations of mechanical knowledge second order propositions.[6] Their purpose is not directly the presentation of mechanical knowledge *per se*, but is a part, however it was understood, of a comprehensive attempt to lay out a structure of what can be known, how we know it and how we act on it, to be applied chiefly in a polemical or disputational context. This makes the content of these texts at least one step removed from objective description.

Facile descriptions and generalisations about early Chinese belief systems and religious practices often obscure and confuse more than they reveal or explain, but one (absent) feature of Warring States period religion seems apparent: the Chinese spirit realm, however it was perceived, did not have the inexorability of the gods of, for example, the ancient Near East, nor did it compel anyone ever to construct or to breech a personal code of ethics. By the same token, there was no inclination to invoke any kind of supernatural power or pantheon of deities to validate the authority of one's own preferred set of social and ethical doctrines and beliefs. Such claims were instead vested entirely within the domain of human history, even if that history might be a euhemerized (*renversé*) version of what was originally in some sense a body of religious beliefs. The most typical and well-accepted means to establish that kind of authority was to trace a given doctrine back to a revered figure of the past, or to associate it with the name, and thus *de facto* with the teachings, of such a figure. The Mohists rejected this convention, insisting that mere association with an individual, no matter how revered, was not a satisfactory basis for arguing the validity or authority of any ethical doctrine. Their arguments are examples of how, instead, a conclusion, even when apparently based

only on observation, can be defended rigorously from an initial set of definitions and propositions, and they constitute in this regard a set of claims about knowledge that purports to be distinct from both impressionistic judgments and dogmatic doctrines whose ostensible validity arises from no more than an *a priori* association with a traditionally respected or revered historical or legendary figure.

That the Mohists preferred to reason objectively from a fixed starting point, building their arguments logically as they proceed, rather than invoking the name of some traditionally renowned figure (especially that of Confucius) as the primary basis for a claim to authority or vailidity, is evident from the opening lines of the entire Later Mohist corpus. The first canon is a definition of the word *guh* 故 usually understood as 'reason', 'cause', but more precisely meaning something like 'fixed basis' or 'precedent' upon which something, including an argument, is founded:

A 1 C: 故。所得而後成也。

E: 小故，有之不必然，無之必不然。最前之體也。若有端。

大故，有之必然，無之必不然。

Canon: 'Basis/precedent/(cause)'; that which is gotten hold of before anything else is achieved.

Explanation: 'Minor basis': having it, something [still] will not necessarily be so; [but] lacking it, something will necessarily not be so. It is that structural unit [*tii* 體, on which see the next entry] that precedes all others; as if having a starting point. 'Major basis': having it means something will necessarily be so; lacking it means something will necessarily not be so.

A 'minor basis' in other words is one that is necessary, but not sufficient; and a 'major basis' is both necessary and sufficient, for whatever outcome is at issue.[7]

The second item in the canons section is then a definition of the term *tii* 體 'structural unit':

A 2 C: 體。分於兼也。

Canon:[8] 'Structural unit'; a division in the all-inclusive.

Both of the terms *guh* 故 and *tii* 體 are presented as objectively precise; neither is vague, and it is only after setting these out that the Mohist introduces his definitions of 'wits', 'cogitation', 'knowing', and 'understanding'.

The basis of the Later Mohist conception of what can be known and how we know it is given in section A 80, which specifies three sources and four kinds of knowledge:

A 80 C: 知。間 (> 聞?)，說，親。名，實，合，爲。

E: 傳受之，聞也。方不庳，說也。身觀焉，親也。所以謂，名也。所謂，實也。名實耦，合也。志行，爲也。

Canon: 'Knowing': [*via*] an interstice removed,[9] explanation/persuasion, first-hand; [consists in] name, substance, correspondence, behaviour.

Explantion: To receive it *via* transmission is 'hearsay', that "a square will not rotate"[10] is [an example of] 'explanation/persuasion',[11] to be witness to it oneself is 'first-hand'; that whereby one refers to something is 'name', the thing referred to is 'substance', name and substance matched is 'correspondence', intent enacted is 'behaviour'.

Section B 10 goes hand in hand with A 80 in that it identifies the kinds of 'doubt' or '(mis)presumption' that may arise in connection with each kind of knowledge that A 80 has set out:

B 10 C: 疑。說在逢，循，遇，過。

E: 蓬 (> 逢)爲務 (> 霧) 則士爲牛，廬者夏寒，蓬 (> 逢)也。舉之則輕，廢之則重，非有力也。 沛從削，非巧也，若石羽，楯 (> 循)也。鬬者之敝也，以飲酒若以日中，是不可智也，愚 (> 遇)也。智與，以已爲然也與，愚(> 過)也。

Canon: 'Mispresumption': explanation lies in 'obstacle', 'congruence', 'coincidence', 'transience'.

Explanation: When the obstacle constitutes a fog, then a person may become [misperceived as] an ox; or one in a shed in the summertime may become cold; these are due to 'obstacles'.

('*Mispresumption' in regard to matching the name with the substance; allowing one to place what ought to be in category A instead into category B.*)

When one lifts something and deems it light, or putting it down, deems it heavy (like a stone or a feather),[12] this is not out of a consequence of his strength; or to shave wood following the taper, this is not out of a consequence of his skill; these are due to 'congruence'.

('*Mispresumption' in regard to behaviour, i.e., drawing the wrong conclusion because of the easy congruence of the observed behaviour and what might be concluded; the latter not necessarily following from the former. Lifting something light does not warrant the*

presumption of strength as a feature of the lifter.)

> A fighter's demise, whether owing to wine or owing to the mid-day sun, cannot be known; this is due to a 'coincidence' [of factors].

('*Mispresumption' in regard to substance; owing to a coincidence of causes.*)

> Is it 'knowledge' or is it 'taking the already-over to be so'? This [misperception] is due to 'transience'.

('*Mispresumption' in regard to temporary validity vs. logical necessity owing to the possibility of changing circumstances.*)

The effect of the two sections A 80 and B 10 taken together is to summarize the kinds of knowledge the Mohist admits, how it may be gained, and the ways in which it may be misperceived or misapprehended, and in this way to lay out a starting point for a systematically structured approach to logical and rigorous argument that seems ultimately to have been designed to show that a program of ethics need not take the presumptions of the so-called "Confucians" (better: Ruists 儒家) as a foundation, but could and should be established on the basis of an objective understanding of given human behaviour defined in *a priori* terms of 'the desired' and 'the disliked'.[13] This is a central part of the "complex of thought and activity seen in its original circumstances" that Lloyd and Sivin insist is a necessary requirement for meaningful comparison, and we for our part must recognize that a correct understanding of the import of the mechanics sections of the Later Mohist documents depends on seeing those texts as a part of this overall disputational program, not simply as representations of objective observations or inferences. Only from this perspective will we be able to say anything useful and valid about the extent to which the Later Mohist documents reflect a mechanical knowledge comparable to that known in the classical West.

Notes

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[1] Jürgen Renn (ed.), *Galileo in Context*. Cambridge: CUP, 2001; p. 2. (Emphasis original.) For further exploration of this same thesis see Jochen Büttner, Peter Damerow, Jürgen Renn, Matthias Schemmel, and Matteo Vallariani, *Galileo and the Shared Knowledge of his Time*. Berlin: Max-Planck-Institut für Wissenschaftsgeschichte, 2002. Preprint 228.

[2] Geoffrey Lloyd and Nathan Sivin, *The Way and the Word*. New Haven and London: Yale University Press, 2002.

[3] *op. cit.*, p. 6.

[4] *op. cit.*, p. 3.

[5] A. C. Graham, *Later Mohist Logic, Ethics and Science*. Hong Kong: Chinese University Press (Chinese University of Hong Kong) and London: School of Oriental and African Studies (University of London), 1978; p. 24 *et passim*.

[6] See, for example, Yehuda Elkana, The Emergence of Second-order Thinking in Classical Greece, in S. N. Eisenstadt, ed., *The Origins and Diversity of Axial Age Civilizations*, Albany: SUNY Press, 1986, pp. 40-64, and Y. Elkana, Experiment as a Second-order Concept, *Science in Context* 2 (no. 1, 1988), pp. 177-96.

[7] For the restored text, see Graham, *op. cit.*, p. 263.

The Eastern Han *Shuowen jieetzyh* 說文解字 lexicon by Sheu Shenn 許愼 (comp. A.D. 100) defines the word *guh* 故 as 使爲之也 'what *causes* [something] to become such,' introducing the notion of 'agency' or 'causation' explicitly into the picture. The Ching philologist Duann Yuhtsair 段玉裁 (1735-1815) in his commentary to this *Shuowen* entry said 凡爲之必有使之者 "In general when something becomes such, there must be something that caused it." And this, he then said, shows that Sheu Shenn based his definition of *guh* 故 on the *Mohtzyy* line. Duann's contemporary Bih Yuan 畢沅 (1730-97) claimed in the same vein that Sheu Shenn's meaning was precisely the same as that of Mohtzyy (墨子說與許義正同). But in fact 'causation' and 'basis' are distinguished from each other in the Canons; note the following

A 77: C: 使。謂，故。

E: (使)。令，謂也。不必成。

濕，故也。必待所爲之成也。

Canon: 'Causing': by comment, by basis/reason.

Explanation: ('Causing'): An order is 'by comment'; it is not necessarily acted upon. Dampness is a 'basis'; [but] one must await the result of what it induces.

The distinction that the Mohists are insisting on seems to be that the term *guh* 故 carries a causative sense only after the fact; that is, something is recognized as a 'cause' only after the consequence has come about. "Dampness" is not intrinsically or inevitably a cause of anything, but if it leads to mildew, for example, or a bout of ill health, it then can be recognized as a 'cause'. An order, by contrast, has *ipso facto* a causative sense to its meaning, whether or not its outcome is realized. This shows that *guh* 故 can be understood in some cases or in some sense as a type of 'causation', but it does not necessarily follow that the notion of 'agency' or 'causation' was to be taken as an inherent aspect of the word *guh* 故 fundamentally (thus, I have put the gloss 'cause' in parentheses in the translation of A 1 above.) By the same token we are told explicitly that there is a type of 'causation' that has nothing to do with *guh* 故.

Neou Shuhyuh 鈕樹玉 (1760-1827) seems to have seen this difference and made this point in his own notes to Duann Yuhtsair's commentary, disagreeing with Duann and saying instead that Sheu Shenn's meaning was not the same as that in the *Mohtzyy* (墨義與許不同).

For the complete texts of these Ching commentaries on the *Shuowen*, see Ding Fwubao 丁福保, *Shuowen jieetzyh guulin* 說文解字詁林, [Shanghai: Commercial Pr., 1932; rpt. Taipei: Commercial Pr., 1959], p. 1329. For further remarks on the meaning of *guh* 故 and its word family affines, see William G. Boltz, Notes on Chinese etymology: The past and present of *ku* 古 'past' and *chin* 今 'present'. *Oriens Extremus* (Hamburg), vol. 35, nos.1/2 [1992], pp. 35-43.

[8] There is no identifiable extant Explanation for this Canon. See Graham, *op. cit.*, p. 265.

[9] The received *Daw Tzanq* text has *jian* 間 'interstice' here, but on the basis of the matching *shuo* "Explanation" passage, which has *wen* 聞 'to hear', *i.e.*, "hearsay" in the corresponding spot, coupled with the obvious graphic resemblance between the two characters at issue and the ease with which one could be misread for the other, and finally in view of what would only seem reasonable, the *jian* 間 is not surprisingly often emended to *wen* 聞. All the same, and in spite of the reasonableness of the arguments for emending the text, the *jing* passage is completely understandable and in fact sensible and consistent as it stands: one means for acquiring knowledge is at a step removed, an **interstice**, in other words, *contra, e.g.*, *chin* 親 'personally, at first hand', the last-listed of the specified ways. It does not seem to me altogether impossible that *jian* 間 'interstice' could have appeared in the "Canon" and *wen* 聞 'hearsay' in the "Explanation".

Parts numbered by Graham A 1 through A 87 all have the appearance of being definitions of terms. Numbers A 52 through A 69 in particular appear to be geometrical definitions, and seem to match propositions numbered B 17 through B 31, which include the mechanics passages. Among these geometrical definitions we find both *yeou jian* 有間 'having an interstice/interval' (A 62) and *jian* 間 'intervening' (A 63), as follows (angle brackets mark characters inserted by Graham):

A 62:	C:	有間，<不及>中也。
	E:	(有間)。謂夾之者也。
Canon:	"Having an interstice/interval": <not reaching to> the center.	
Explanation:	(Having an interstice/interval); refers to those things that flank it.	
A 63:	C:	間，不及旁也。
	E:	(間)。謂<所>夾者也。尺前於區穴而後於端，不夾於端與區穴。及及非齊之及也。
Canon:	"Intervening": not reaching to the sides.	
Explanation:	(Interstice/interval); refers to <that which is> flanked; a measurement from the outline and to the starting-point is not flanked by starting-point and outline. The two 'reachings' are not isometric 'reachings'.	

These two definitions may not seem to bring perfect clarity to the use of *jian*, but they do show that there was a formal recognition of this as a feature of discontinuity, and that could readily have been seen as applicable to the acquisition of knowledge just as it was in the sphere of measurements.

[10] The character appearing in the received *Daw Tzanq* text is 庳, a graph otherwise unattested. Basing himself on earlier explanations of Suen Yiranq and Wu Yuhjiang, Graham understands this anomalous graph as a mistake for 庫, which in turn is taken as 厙 . This he then recognizes as interchangable with 軍, originally 𠂤 (because of the graphic overlap of 厂, 勹 and 冖), which for its part is then taken finally as standing for the word *yunn*, conventionally written 運. (*op. cit.*, p. 83.)

[11] The 'circle' and the 'square' and their empirical incompatibility is one of the Later Mohist's stock examples, here illustrating knowledge of the 'explanatory' kind, *i.e.*, seeing that it is objectively so.

[12] The three-character phrase *ruoh shyr yeu* 若石羽 seems to be misplaced in the received text and probably should be transposed with the comment about 'shaving wood', as the translation suggests.

[13] Graham, *op. cit.*, pp. 44-52.