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Approach to Time in Ancient Greek Philosophy[1]

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This paper clarifies Aristotle's definition of time as 'the number of movement by reference to before and after', by taking into consideration other concepts of time, such as that of Plato or of the Stoics, as well as various metaphors concerning time: the Ego-Moving metaphor and the Time-Moving metaphor; the sagittal metaphor and the lateral metaphor. The lateral metaphor does not appear in our language use, but when we visualize time, we allocate past or future to the right or left (or up or down), following the direction of our writing and reading. Time doesn't seem to exist, the past being no longer, the future being not yet, and 'now' being no part of time. However, humans have the faculty of imagination or representation (*phantasia*), closely related with memory, and thus by allocating time in our imagination, we can imagine it as some movement developed in space on our spiritual wax of mind, where perceptions are impressed, putting past times, for example, to the left, and future times to the right. This paper also takes into account the difference of two main types of clock in ancient world, the sundial and the water-clock, to further the understanding of Platonic *versus* Aristotelian concepts of time. Finally in relation with movement, the difference between eternity and sempiternity as well as the question of divisibility and indivisibility of movement and time is also discussed.

Keywords: time, movement, Aristotle, Plato, clock, memory

1. Does Time Exist?

In Japanese 光陰矢の如し (*Kōin Yano Gotoshi*, Light and shadow just like an arrow). Time is conceived as something closely related with motion, and with day and night, namely, the sun.

The philosopher who developed the most systematic explanation of time in Greek philosophy was Aristotle (384–322 BCE). He raised a puzzle at the beginning of his discussion on time in *Physics* Book 10 (Chapters 10–11, 217b32–218a8).

> [T1] Some part of time is past and is not, while another part is future and is not yet. Time is composed of these parts. But it seems impossible for 'what is composed of things that are not' to partake in any being. How about 'now' (in which we do actually live)? Does it not exist? But 'now' is no part of time. 'Now' is rather a boundary between the past and the future (just as a point is a boundary without any size, dividing a line).

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The present is present, and thus it seems to exist. However, if the present has any extension, it can be divided into its parts, which are the past, the present and the future, and if this present has any extension again, it can be divided into the past, the present and the future, and this process of division will certainly continue *ad infinitum*, as long as the present newly found has some extension. Rather, the present in the strict sense is supposed to be a mere point, without any size. This mere point is 'now', and this 'now' seems always to be passing into the past.

The definition of time Aristotle reached in the *Physics* is expressed in the following sentence:

> [T2] It is clear that time is the number of movement by reference to before and after, and that it is continuous (for it belongs to what is continuous). (*Physics* 220a24–26)

What does he mean by this enigmatic definition? But before tackling this question, I would like to consider the relationship between time and movement from a wider perspective, the perspective of most recent studies on metaphor.

2. What Moves in Time and to What Direction?

There are two ways of metaphorically representing the movement to do with time (Figure 1). According to the Ego-Moving metaphor, Ego progresses along the time-line toward the future, with time as the ground, as in 'We are approaching Christmas', which we say, for example, in November. But after Christmas, for example, in February, we say 'Christmas is *behind* us', and 'Easter is *before* us'. According to the Time-Moving metaphor, on the other hand, various events move from the future to Ego as the ground, and after passing Ego, become the past. Time is here imagined as a river or a conveyor belt, on which 'Easter is approaching', and 'Thursday is *before* Saturday'.[2]

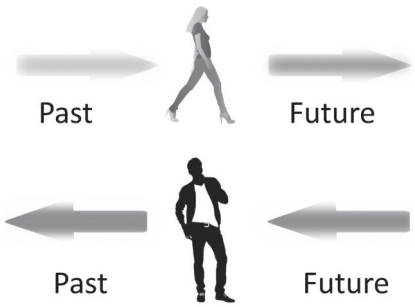

Figure 1: Ego-Moving & Time-Moving Frameworks

How will you answer the following question? 'Next Wednesday's meeting has been moved forward 2 days. Which day is the meeting now that it's been moved?'[3] People whose answer is 'Friday' are thinking of time in the Ego-Moving framework. People whose answer is 'Monday' are adopting the Time-Moving framework. Those who have just been moving (for example, traveling on a train), or imagining self-motion, tend to adopt the Ego-Moving perspective, while those who have had an image of a sequence of cubes moving across a screen horizontally tend to adopt the Time-Moving perspective.[4] Also people who adopt the Ego-Moving perspective (responding 'Friday') seem to show higher anger trait scores, stronger sense of personal agency, and higher procrastination scores than people who adopt the Time-Moving

2 Lakoff (1980) 43–44; Boroditsky (2000); Torralbo et al. (2006); Duffy et al. (2014).
3 McGlone & Harding (1998); Duffy et al. (2014).
4 Núñez and Sweetser (2006).

perspective (responding 'Monday').[5]

However, whether the subject that is moving is Time or Ego, what is in *front* of us is, as a matter of fact, the same in both perspectives, namely, a future event, and what is *behind* us is a past event.[6] However, there is another way of representing time, according to which something in the past is in *front* of us, and something in the future is *behind* us. According to the time model of Toba,[7] time first moves up from below, and then becomes visible in front of the observer as recent past. After that it moves up out of the view, and ends up as remote past, from where time again emerges as remote future, and then it comes back down, moving behind the observer, as immediate future, and after that it becomes present time (Figure 2).[8] Also in Aymara[9] future is *behind* Ego and past is in *front* of Ego. In this language the basic word for 'front' (*nayra*, 'eye/front/sight') is also a basic expression meaning 'past', and the basic word for 'back' (*qhipa*, 'back/behind') is a basic expression for 'future'; when a man is discussing 'tiempo futuro' (future time), he gestures with his right hand across his body and points backward, contralaterally over his left shoulder, exactly at the moment when he says 'futuro'. This representation of the past as lying in front and the future behind seems to come from the fact that we cannot see the future, but can see or know the past.[10]

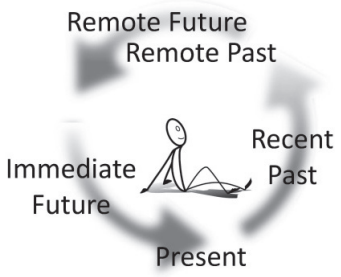

Figure 2: Toba Time

But usually the future is in front, and the past is behind. This is the *sagittal metaphor*, with past times being mapped to the back and future times to the front.[11] However, we also use the *lateral metaphor*, in which the past is mapped to the left or right and the future to the right or left. This metaphor does not appear in our language use; there is no language in which a word that means right or left is employed to represent future or past. However, when we visualize time, we allocate past or future to the right or left, and this tendency is observable in our gesture and reaction as well.[12]

Usually, English speakers (who write left to right) tend to put the past times to the left and future times to the right, whereas Hebrew or Arab speakers (who write right to left) tend to arrange past times to the right and future times to the left.[13] We, Japanese, on the other hand, when writing or reading horizontally, put the past times to the left and future times to the right, but when vertically, put the past to the right and the future to the left, as the movement from one line to next is from the right to the left. But either way, time is visualized as moving

5 Bender et al. (2010); Núñez and Cooperrider (2013); Duffy et al. (2014).
6 We say, 'I can't face the future', 'Troubles lie ahead', 'I look forward to seeing you', and 'That's all behind us now', 'That was way back in 1900', and 'Look back in anger'. Cf. Radden (2003), (2011).
7 An Amerindian language spoken in South America.
8 Radden (2003), (2011); Núñez and Cooperrider (2013).
9 An Amerindian language spoken in the Andean highlands of western Bolivia, Peru and Chile.
10 Núñez and Sweetser (2006); Santiago et al. (2007); Núñez and Cooperrider (2013).
11 On sagittal metaphor and lateral metaphor, cf. Núñez and Cooperrider (2013); Walker and Cooperrider (2016).
12 Santiago et al. (2007); Casasanto and Jasmin (2012); Walker and Cooperrider (2016).
13 Fuhrman and Boroditsky (2010); Fuhrman et al. (2011); Cassanto and Jasmin (2012); Núñez and Cooperrider (2013); Maass et al. (2014).

horizontally. However, there is another representation of time, which moves from up to down. Mandarin speakers use not only 前 (*qián*, front) and 后 (後) (*hòu*, back) to refer to an earlier thing and a later thing, respectively, but also use 上 (*shàng*, up) and 下 (*xià*, down) in referring to events that occur in a time-line. 上月 (*shàngyuè*, literally, 'up-month') is 'last month', and 下月 (*xiàyuè*, literally, 'down month') is 'next month'.[14] In Japanese too, 上 (*kami*, *jō*, up) and 下 (*simo*, *ge*, down) can be used to mean 'early' and 'later', just as 上半期 (*kami-han-ki*, the first half of the year), 下半期 (*simo-han-ki*, the second half of the year); 上巻 (*jō-kan*, the first volume), 中巻 (*chū-kan*, the second volume), 下巻 (*ge-kan*, the last volume); 上旬 (*jō-jun*, the first ten days of a month), 中旬 (*chū-jun*, the middle ten days of a month), 下旬 (*ge-jun*, the last ten days of a month).[15] One of the reasons for this vertical conception of time seems to be the tradition of writing from up to down.[16] Also the river model of flowing time may have reinforced the representation of time as moving from up to down. In this context the cultural importance of the Yangtze River (揚子江) is sometimes mentioned as a contributing factor.[17]

However, what moves downward is not limited to the river. Because of gravity, most of things that are movable around us move downward. Thus even in English, time tends to be viewed as flowing down from the earlier time into the present, with the past being located up and the present down, as is in 'These stories have been passed *down* from generation to generation' or 'This tradition has lasted *down* to the present day'. But what is interesting is that this flowing *down* does not go beyond the present time into the future. We say 'This tradition will last into the future', not 'This tradition will last *down* into the future'.[18] There is the solid ground on which we stand. If there is anything under the ground, then it is the underworld or Hades or Tartarus in Greek myth, and we don't like our future falling down into the abyss. Rather future should come up from the horizon, just like the sun. Thus we say, 'The new year is coming *up*'.

Our representation of time is certainly under the influence of moving things around us, especially the river and the sun. Pormpuraawans[19] also arrange time according to the sun, that is, according to cardinal directions: east, west, north, and south, which are determined by the movement of the sun. They say things like 'Move your cup over to the north-north west a little bit' or 'The boy standing to the south of Mary is my brother'. In their perception of time, when one is facing south, time flows from the left to the right, when facing north, from the right to the left, when facing east, toward the body, and when facing west, away from the body.[20]

14 Boroditsky (2001); Chen (2007), who is a little more careful, warning against putting too much emphasis on Chinese representation of time moving from up to down; Raddan (2003), (2011); Miles et al. (2011); Núñez and Cooperrider (2013).
15 Raddan (2011).
16 Raddan (2011); Fuhrman et al. (2011).
17 Raddan (2011).
18 Radden (2003).
19 People living in Pormpuraaw, a remote Australian Aboriginal community.
20 Boroditsky and Gaby (2010).

3. Time, Movement and Images

We think of time by relating it to some movement, of the sun, the river, or anything else that is moving. Here it is important to note that this relationship between time and space is asymmetrical. We more often conceptualize time in terms of space than space in terms of time.[21] According to theories of metaphorical mental representation, it seems that not only representations of time and quantity, but also those of preference, emotional valence, intimacy, etc. depend asymmetrically on representations of space.[22] What does this mean concerning our cognition of time?

According to Aristotle, our cognition develops in the following order: (1) each sense-perception registers momentary affections, which is possible even for many irrational animals; (2) some irrational animals have not only sense-perceptions but also memory and imagination; (3) there are also a very limited number of animals that have also some experience; (4) human beings have also a share of intellect (*Metaphysics* 980a21–981a1).

According to *On Memory and Recollection* by Aristotle, when momentary affections are registered through senses, some of them are, as it were, stamped in the soul,[23] so as to remain as images, constituting memory (450a27–32). Memory is an image kept as an impression stamped in the wax-like stuff of the soul, the model to be later developed into *tabula rasa* in the tradition of occidental philosophy. Thanks to the memory in this spiritual wax, some animals can perceive movement and time, by means of what Aristotle calls 'common sense'. 'Common sense' (*koinē aisthēsis* in Greek; *sensus communis* in Latin), which is also called by Aristotle 'the primary faculty of perception' (*prōton aisthētikon*), is different from what we usually understand by 'common sense', which is 'good sense and sound judgement in practical matters'.

Images (*phantasmata*) are necessary for animals to act, and besides, for humans also to think. In engaging, for example, in geometry, we need to have recourse to visual images scratched on the wax-like staff of our mind. According to Aristotle:

> [T3] A person who engages in thinking, even if he does not think about magnitude, puts a certain magnitude in front of the eyes, … It is necessary to grasp magnitude and movement with the faculty with which one grasps time, and the image is an affection of the common sense; … Memory, even memory of the intelligible objects, does not occur apart from image. … Therefore, memory is possessed not only by human beings …, but also by some other animals. (*On Memory and Recollection* 450a4–12)

Images are held as something having location and extension, and on the basis of this visualization in space we can talk about time and quantity. As we saw above, time does not seem to exist. However, according to Aristotle:

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21 Clark (1973) 56ff.; Lakoff and Johnson (1980), (1983); Casasanto and Boroditsky (2008); Casasanto et al. (2010).
22 Casasanto et al. (2010).
23 Or the part of the body related to perception.

[T4] Concerning the present we have perception (*aisthēsis*); concerning the past we have memory (*mnēmē*); concerning the future we have expectation (*elpis*). (*On Memory and Recollection* 449b26–27)

Even though the past is no longer, and the future is not yet, and 'now' is no part of time, we can imagine time as some movement developed in space on our spiritual wax, for example, putting past times to the left, and future times to the right.

4. 'Now' in Two Senses

Besides, our actual present has some length, in contrast to 'now' in its strictest sense. Aristotle himself acknowledges not only 'now' in the strict sense, but also 'now' which extends toward both the past and the future (*Physics* 222a20–24). 'Now' in the non-strict sense is such 'now' as we use in 'he will come now' (if he will come today), and 'he has come now' (if he came today). But the Trojan War has not happened now, although time is continuous towards it, because it is not near the 'now'.

Later in Hellenistic philosophy, Stoics also regarded time as continuum, which is infinitely divisible, treating the past and the future as parts of time, and taking 'now' as the boundary between the past and the future. However, they also admitted two kinds of the present just like Aristotle.

[T5] He [Posidonius, c.135–c.50 BCE] defines time as 'interval of movement or measure of speed and slowness'. And concerning the time … he holds that part of it is the past, part is the future, and part is the present. And the present consists of part of the past and part of the future, encompassing the dividing boundary itself. But the dividing boundary is point-like. 'Now' and the like are thought of broadly and not exactly. But 'now' is also spoken of with reference to the least perceptible time encompassing the dividing boundary of the future and the past.[24]

5. Definitions of Time by Plato, Aristotle and Stoics

Posidonius defined time in [T5] as 'interval (*diastēma*) of movement or measure of speed and slowness'. 'Interval' was the concept the Stoics employed in discussing time.

[T6] Zeno of Citium [the founder, 334–262 BCE] said that time is the interval of all movement without qualification, but Chrysippus [leading Stoic philosopher, c.280–c.206 BCE] said that time is the interval of the world's movement.[25]

[T7] Chrysippus said that time is the interval of movement according to which the measure of speed and slowness is spoken of; or the interval accompanying the world's

24 Stobaeus 1.8.42.14–24; Posidonius fr. 98; Long and Sedley 51E.
25 Simplicius, *On Aristotle's Categories* 350, 15–16; *SVF* 2.510; Long and Sedley 51A.

movement.[26]

Aristotle's definition of time was 'Time is the number of movement by reference to before and after'. This looks different from Stoic definition of time given in terms of 'interval'. But 'interval' is produced just by being sandwiched between 'before' and 'after'. Thus there is no significant difference between the definition in terms of 'before and after' and that in terms of 'interval'.

However, the element of 'number', which is central in Aristotle's definition, is lacking in Stoic definitions. What is the point of inclusion or absence of 'number'? Before entering this question I would like to see Plato's definition, for Aristotle himself begins his discussion on time by referring to it (*Physics* 218a31–b9).

Plato's definition is expressed in the *Timaeus*, with the reference to the world's movement, just like Stoic definitions.

> [T8] Because the model at which the demiurge looks is an eternal living being, he tried to make the world similar to it to the highest degree. But because it is impossible to attach complete eternity to what is generated, he planned to make eternity's moving image, and because eternity remains in one, he made its eternal image, which goes according to number, and this is what we now call time. For simultaneously with the construction of the heaven he contrived the generation of days and nights and months and years, which are all parts of time, while 'was' and 'will be' are its generated forms, although we unknowingly make a mistake of applying them to eternal being. For we say that it 'was, is, and will be', whereas only 'is' is appropriate to eternal being. 'Was' and 'will be', on the other hand, are appropriate to be applied to becoming which goes in time, since both of these are movements. (*Timaeus* 37D–38A)

Time, which is eternity's moving image, going according to number, is thought of as going around, because the universe which is created as similar as possible to the eternal living being moves a circular movement. Aristotle's definition of time as 'the number of movement by reference to before and after', on the other hand, does not include circularity as its indispensable element.

In presenting his definition, Aristotle starts from the fact that time is observed with movement or change:

> [T9] When we don't experience any change in our thought, or, even if we do, when we don't notice it, no time seems to have passed. For example, when we sleep, time doesn't seem to have past, because on such an occasion we combine the 'now before' with the 'now after', and make them one, eliminating the time between them which we did not perceive. It is when we perceive movement that we perceive time simultaneously. If some or other movement is in the soul, it seems to us that time has passed, even when it is dark and we feel no bodily sensation. (*Physics* 218b21–219a10)

26 Stobaeus 1.8.42.25–28; *SVF* 2.509; Long and Sedley 51B.

[T10] And when we mark (*horisōsin*) movement by marking the before-and-after, we recognize time. We say time has passed, when we have the perception of the before-and-after in the movement, with our soul pronouncing that there are two 'nows'—'now before' and 'now after'. For what is marked by 'now' seems to be time. (219a22–30)

[T11] Thus, as long as we perceive 'now' as one, and not as 'before' and 'after' in the movement, … no time seems to have passed, for there has been no corresponding movement. But when there is the before-and-after, we say that there is time. For this is just what time is: the number of movement by reference to before and after. (219a30–219b2)

[T12] But 'number' is spoken of in two ways: we apply the name 'number' to what is being counted and what can be counted, and also to the thing by means of which we are counting. And time is what is being counted, not the thing by means of which we are counting. (219b5–9)

Here a question naturally arises. What is the subject that counts movement, and by means of what? The reply to the second question is 'by means of 'now''.

[T13] 'Now' marks (*horizei*) time as before and after. … What is true of a point is also true of the travelling thing by means of which we recognize the movement, and the before and the after in it. … And just as time corresponds to movement, 'now' corresponds to the travelling thing; for we recognize the before-and-after in movement by means of the travelling thing, and the thing by means of which the before-and-after becomes countable is 'now'. … While time is the number of travel, the now is, as it were, the travelling thing, as a sort of unit of number. (219b10–28, 220a3–4)

Thus, the unit by means of which movement is counted is 'now'. As to what counts movement, he says as follows:

[T14] If there could not be something to do the counting, there would not be anything countable, and therefore there would be no number. … Thus if nothing but the soul and the intellect in the soul can count, there would not be time, if there were no soul. (223a22–26)

The conditional, 'If nothing but the soul and the intellect in the soul can count', suggests that Aristotle may have allowed for a possibility of something other than the soul counting time. But whatever his view might have been, the principle counter of time is our soul. This seems to make Aristotle's conception of time somewhat subjective.

In contrast to Aristotle's definition, neither Platonic nor Stoic definition of time involves 'counting number'. Their view of time is thus less subjective than Aristotle's. For them time exists not by relying on some such counter as the soul; it exists as something dependent on eternal being (in Plato), or dependent on any movement (in Zeno), or dependent on the

world's movement (in Chrysippus).[27]

6. Sundial and Water-clock

In order to have concrete images of Plato's definition of time as well as Aristotle's, it may be useful to see what kind of clock was employed in ancient Greece and Rome. There were two main types. One was the sundial (Figure 3).[28] Herodotus says in his *Histories* (2.109) that 'The Greeks learnt *polos* and *gnōmōn* and the twelve parts of the day from the Babylonians'. The *polos* was a concave basin, shaped like the vault of heaven, on which the shadow was cast by the *gnōmōn*, the vertical staff set up as a 'pointer'.

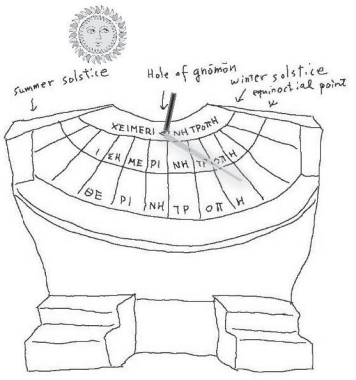

Figure 3: The Sundial at Pythagoreion in Samos

Platonic conception of time as eternity's moving image, going according to number, like the heaven going around, is very well represented by this sundial, on whose concave surface the *gnōmōn*'s shadow moves during the daytime from one part, on which a number was sometimes carved, to the next part, on which the next number was carved.

The other version was the water-clock (*clepsydra*), which was used, from at least the second half of the fifth century BCE, originally in the Athenian court to measure the time allowed for orators to speak (Figure 4).[29] It was used, for example, at Socrates' trial. The common type consisted of two vessels, with water flowing from the spout of the one above into the one below; it was in use at least until the end of the fourth century BCE.[30] In the Athenian Agora the structure of a water-clock, made of blocks of limestone, was excavated at its southwest corner, facing north on the open square, close to major public buildings. It was used from the fourth century until the early second century BCE, for anyone visiting the agora square to see it and know the time.[31]

Figure 4: Water-clock in the Athenian court

The defect of the water-clock (out-flow type) was that the trickle is fast when the vessel

27 Long and Sedley (1987), vol.1, 306–7.
28 Pythagoreion (Samos), Arch. Museum, Inv. 322 (2nd half of 2nd C. BCE)
29 Water-clock used in the Athenian court. ΑΝΤΙΟΧΙΔΟΣ (Antiochidos) = the name of a tribe; X = χοῦς (choe = c.3.4 liters).
30 Young (1939). The letters, 'X X', written on the vessel means ΧΟΥΣ ΧΟΥΣ (*chous chous*), i.e. two ΧΟΕΣ (*choes*), which is about 6.8 liters.
31 Camp II and Armstrong (1977).

above is full, and becomes gradually slower as the pressure of the water decreases, though this defect seems to have been rather useful for those in the court to know that the time limit of the orator's speech was approaching.[32] In order to remove this defect, the water-clock in the Agora was later changed from the out-flow type to the in-flow type (Figure 5).[33] An Alexandrian inventor Ctesibius (fl. 285–222 BCE) also improved the water-clock by making the adjuster whose floating cone could keep the trickle of the speed constant (Vitruvius, *De Architectura* 9.8.4–7) (Figure 6).[34]

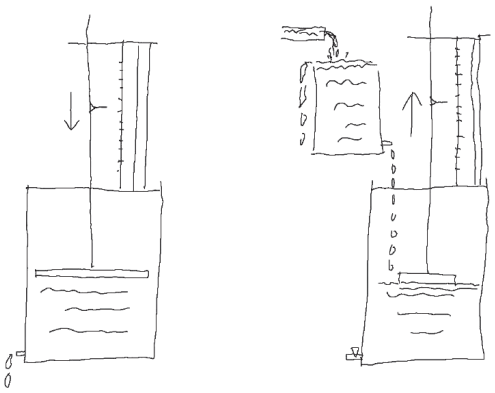

Figure 5: Water-clock in the Agora

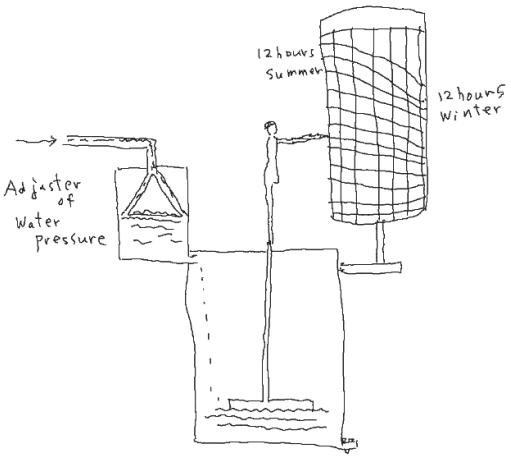

Figure 6: Water-clock of Ctesibius

However, an interesting thing was that they didn't try to employ the steady trickle of the in-flow-type water-clock as the standard unit by means of which they count the flow of water. Their standard clock was rather the sundial, in which the period from sunrise to sunset was divided into twelve parts, each of which is an hour (*hora*), but because the length of that period varied from month to month, the length of an hour also varied from month to month. They thus tried to adjust the regular time of the water-clock to the irregular time of the sundial, by making the pointer of the former indicate a different division of daytime as a year proceeds, just as we can observe in the water-clock of Ctesibius. The adjustment of time was necessary not only according to the season but also according to the latitude; the sundial captured in Sicily in 263 BCE and set up on a column behind the Rostra in Rome was not accurate because of the difference in latitude.

Even though such people as astronomers considered the sundial to be useful, the sundial at a public place, which worked only when the sun was shining, was rather a nuisance for ordinary people. Thus a character in a comedy by Plautus (c.250–c.184 BCE) complained this way.

[T15] May gods destroy the man who first discovered hours! Destroy him, too, who first

32 Young (1939), 278.
33 Water-clock in the Agora. Left: out-flow clepsydra (1st period); right: in-flow clepsydra (2nd period).
34 Water-clock of Ctesibius.

> set up a sundial here, which cuts my day so wretchedly into small portions. For me as a boy the belly was my sundial, far best and truest of all these. (Aulus Gellius, *Noctes Atticae* 3.5)

Seneca compared to the disagreement among philosophers the discrepancy the sundial brought about.

> [T16] I cannot tell the exact hour, which is more easily agreed upon by philosophers than by the sundials, but it was between the sixth and seventh hour. (*Apocolocyntosis* 2.2)

7. Subjective, not Arbitrary

Because the principle counter of time in Aristotle was our soul, his conception of time was somewhat subjective. However, this does not mean that time for him was arbitrary. The time of the sundial may be felt slower than the time of the belly for a hungry person. But it is clear for Aristotle that the time of the sundial, not the time of the belly, should be employed as the standard by which to measure other things. He emphasizes the fact that although movement may be faster or slower, time never becomes faster or slower:

> [T17] Movement is faster or slower, but time is not, for 'fast' and 'slow' are defined by time; what moves much in small time is 'fast' and what moves little in much time is 'slow'. (*Physics* 218b13–17, cf. 220a32–b5)[35]

When counting time by means of 'now', we may adopt different lengths of interval marked by 'now before' and 'now after', but as long as a group of people decide on a specific interval and adopt it, there arises no problem, and Ancient Greeks led their lives according to the time of the sundial. According to Aristotle's *On Coming-to-be and Passing-away*:

> [T18] The times and the lives of each creature have a number, and are distinguished by it. For there is an order, and every life and time is measured by a period (cycle, *periodos*); but not all of them are measured by the same period (cycle), but some by a smaller period (cycle), and others by a larger period (cycle). For to some of them the measure is one year, to some a longer period (cycle), and to some a shorter period (cycle). (336b10–14)

Of course, as science develops, there arise situations where one needs to measure, by the uniform standard, the speed of things in different seasons and in different latitudes. The reliable clock for this purpose became available about 2,000 years later when Galileo (1564–1642) discovered the property of the simple pendulum whose period is independent of the

35 Cf. Socrates' definition of speed in the *Laches* (192A–B), which is applicable to its instance in running, harping, speaking, learning, and also in the speed of arms, legs, mouth, voice, or mind: the faculty that gets many things done in a little time.

degree and the speed of the oscillation.[36]

8. Downward Movement and Revolution

When we consider the concept of time in relation with the two main types of ancient clocks, we notice one conspicuous difference between them, which is revolution *versus* downward movement. The downward movement of water in the water-clock, especially the out-flow type, gave people an image of their approach to end. Seneca wrote as follows:

> [T19] We do not suddenly fall into death, but go forward little by little. Every day we die, for every day some part of life is removed, and even when we are growing large, life is growing less. … What empties the water-clock is not the last drop but all that which previously has flowed out. In the same way the final hour when we cease to exist does not alone bring our death but simply completes the process. At that point we have arrived at death, but we have been travelling thither for a long time. (*Epistula* 24.19–20)

Aristotle also drew our attention to the fact that we customarily say, 'time wears things away', and not 'it has become young or beautiful because of time', and notes that time in itself is rather the cause of destruction, because time is the number of movement, and movement removes what is there (*Physics* 221a30–b3). However, he points out that this is only the common way of speech. He does not share Seneca's pessimism.

As we saw above, we ourselves don't say in English, "This tradition will last *down* into the future', but 'This tradition will last into the future', and 'The new year is coming *up*'. Aristotle succeeded Platonic view of time as something imitating the eternal principle, which can be represented by circular movement of the sun. In his case the eternal principle to be imitated was the movement of the thought of the Unmoved Mover which thinks itself, whose movement is then imitated by the circular movement of the world, appearing as the movement of the sun (*Metaphysics* 12.7–10). Even the passing-away of an individual living being was located by Aristotle in this imitation of eternity, as something that returns in a circle to the starting point of a new life, brought about by each creature's achieving its goal of leaving an offspring, in the great teleological cycle of the heavens.

9. Eternity and Sempiternity

But still there is a difference between Plato and Aristotle concerning the imitation of

36 A story says that Galileo, who was then seventeen years old, was so bored during the Mass in the cathedral of Pisa that his attention was diverted to a chandelier swinging gently in the breeze, and then, interested in the oscillation, he began to measure with his pulse the length of the time needed for one swing, and discovered that irrespective of the degree of the swing, completing the swing takes the same number of pulse beats. However, the fact was that his interest in music 'led him to experiment with pendulums of varying lengths for their rhythms', with the case being, quite contrary to the legend, that his first application of the pendulum as a timing device was the attempt to determine the pulse rate of ill patients. The timing device he made use of before developing the pendulum clock was in fact a water clock. Cf. Newton (2004) 51–2.

eternal principles. In Plato's view, the demiurge created time whose parts are days and nights, etc., simultaneously with the heaven, in the exactest-possible imitation of eternity remaining in one ([T8]), and time was thus perishable as a generated thing. It was only thanks to the benevolent intention of the demiurge that time was everlasting without end (*Timaeus* 41A–B); time had beginning and end in principle for Plato. Here a question may be raised. What was there before time began? Or if there was nothing else but the demiurge, what was the demiurge doing before time began? Although not from Plato, the best answer will be given by Augustine:

> [T20] You [God] had made time itself; nor could there any times go past before you had made times. But if before heaven and earth there was no time, why is it demanded what you were doing 'then'? For there was no 'then', when there was no time. Nor do you precede times by time (otherwise you would not precede all times), but you precede all 'pasts' by the highness of eternity always present. And you transcend all 'futures' because they are future [yet to be] and when they come, they will be past, but you are the same yourself, and your years will not wane. (*Confessions* 11.13)

In Plato and Augustine 'eternal' (*eternus* in Latin) is virtually distinguished from 'sempiternal' (*sempiternus*, from *semper*, meaning 'at all times'). What is sempiternal exists at all moments of time, whether time is finite in one or both directions, or infinite in both.[37] What is eternal is, on the other hand, timeless. In their view, 'was' and 'will be', or 'past' and 'future' can be applied to sempiternal time but not to eternity. And thus for them eternity and sempiternity are incompatible.

For Aristotle, on the other hand, the thought of the Unmoved Mover to be imitated by the world is ungenerated and imperishable, and thus the world as a whole as well as time is also ungenerated and imperishable. For him eternity is either identical with sempiternity or related to it by mutual entailment.

10. Divisibility and Indivisibility of Movement and Time

Aristotle takes time to be continuous because it belongs to movement, which is continuous, and movement is continuous because it takes place in space, which is continuous. But there was a tradition in Greek philosophy that does not take them to be continuous. According to Aristotle, continuous things are infinitely divisible (*Physics* 185b10–11, 200b20, 232b24–5, 239a21–2). Atomists, on the other hand, who assumed that there are indivisible things, took different views concerning movement and time.

In the history of Greek philosophy, atomism appears under the influence of the paradoxes of Zeno of Elea (b. c. 490 BCE) concerning movement. They consist of four arguments: (1) Bisection, (2) Achilles (and the Tortoise), (3) Flying arrow, (4) Moving blocks.[38] The first two are based on the supposition that space and time are infinitely divisible, and the last two are based on the existence of indivisible magnitude of space and time. (2) and (4) concern the

37 Kneale (1968/69) 223.
38 Cf. Aristotle, *Physics* Book 6, Chapters 2 and 9.

movement of two things, and (1) and (3) concern the movement of one thing. I here briefly touch (1) and (3). First, (3).

Flying arrow is developed on the supposition that there are indivisible spaces and times, as follows:

> [T21] (a) The travelling arrow is at rest. This follows from assuming that time is composed of 'nows', for if that is not granted, the conclusion will not follow (*Physics* 6.9. 239b30–33). (b) Zeno says, everything always rests when it occupies a space equal to itself, and what is travelling is always in 'now'; then it follows that the travelling arrow is motionless. (239b5–7)

The best way to understand the situation of the arrow in each space at each 'now' will be to think about frames of the film that shows the flight of the arrow. In each frame the arrow is at rest by being in each 'now', while when the frames are shown one after another, the arrow looks as if moving. But the fact is that although the arrow may be said to have moved from frame 1 ('now 1') to frame 2 ('now 2'), there is no time when the arrow is actually moving.

Aristotle himself argues that Zeno's argument of Flying arrow is mistaken, for time is not composed of indivisible 'nows', no more than is any other magnitude (239b9–9). But Leucippus and Democritus (5th century BCE) accepted the supposition of indivisible magnitudes. And later, Epicurus (341–271 BCE), the representative atomist in Hellenistic philosophy, took time to be composed of indivisible 'nows', and claimed that movement is taking place not in time.

Epicurus not only admitted the existence of physically indivisible things, which are his atoms, '*atomon*' meaning 'indivisible', but also assumed that there are smallest units of extension, minimal parts, of which the atom itself consists. The difference of the size of atoms is explained by the number of their minimal parts. The edge of an atom cannot be between the two opposite boundaries of a minimal part, for if it were there, it would become possible to divide the minimal part at the very place of that edge, and it would be no longer the minimal part. Thus, the edge of the atom must be at one boundary of the minimal part, and in the next moment it must be at the opposite boundary of the same minimal part without any time passing, which reduces its movement into a series of staccato jerks, as Aristotle reproached (*Physics* 6.1. 231b25–232a17) (Figure 7).

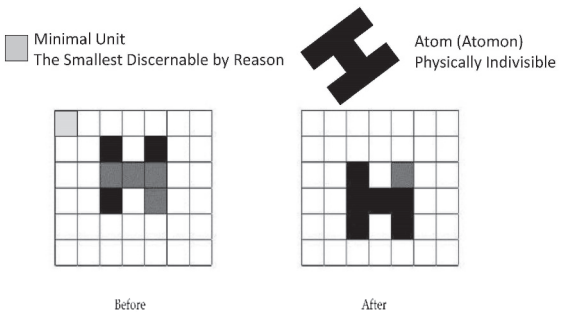

Figure 7: Motion of an atom

As we have seen, Aristotle himself chose the infinite divisibility of magnitude and time. But Zeno found the paradox here too, which is described in (1) Bisection, as follows:

> [T22] Bisection argues that nothing moves, for the travelling thing must first arrive at the halfway points before it arrives at the end … (*Physics* 239b11–13)

The gist of this argument is that it is possible to take infinite number of halfway points, 1/2, 1/4, 1/8, …, but it is impossible for the travelling thing to touch this infinite number of points. But it is now TIME to finish this paper. Otherwise the writing would not end, trying to touch infinite number of points.

Bibliography

Bender, A., Beller, S. and Bennardo, G. (2010), 'Temporal Frames of Reference: Conceptual Analysis and Empirical Evidence from German, English, Mandarin Chinese and Tongan', *Journal of Cognition and Culture* 10, 283–307.

Boroditsky, L. (2000), 'Metaphoric Structuring: Understanding Time through Spatial Metaphors', *Cognition* 75, 1–28.

Boroditsky, L. (2001), 'Does Language Shape Thought?: Mandarin and English Speakers' Conceptions of Time', *Cognitive Psychology* 43, 1–22.

Boroditsky, L. and Gaby, A. (2010), 'Remembrances of Times East: Absolute Spatial Representations of Time in an Australian Aboriginal Community', *Psychological Science* 21, 1635–39.

Camp II, J. M. and Armstrong, J. E (1977), 'Notes on a Water Clock in the Athenian Agora', *Hesperia* 46, 147–61.

Casasanto, D. and Boroditsky, L. (2008), 'Time in the Mind: Using Space to Think about Time', *Cognition* 106, 579–93.

Casasanto, D., Fotakopoulou, O., and Boroditsky, L. (2010), 'Space and Time in the Child's Mind: Evidence for a Cross-Dimensional Asymmetry', *Cognitive Science* 34, 387–405.

Casasanto, D. and Jasmin, K. (2012), 'The Hands of Time: Temporal Gestures in English Speakers', *Cognitive Linguistics* 23, 643–74.

Chen, Jenn-Yeu (2007), 'Do Chinese and English Speakers Think about Time Differently? Failure of Replicating Boroditsky (2001)', *Cognition* 104, 427–36.

Clark, H. H. (1973), 'Space, Time, Semantics and the Child', in T. E. Moore (ed.), *Cognitive Development and the Acquisition of Language*, New York, 27–63.

Duffy, S. E., Feist, M. I., and McCarthy, S. (2014), 'Moving Through Time: The Role of Personality in Three Real-Life Contexts', *Cognitive Science* 38, 1662–74.

Fuhrman, O. and Boroditsky, L. (2010), 'Cross-cultural Differences in Mental Representations of Time: Evidence from an Implicit Nonlinguistic Task', *Cognitive Science* 34, 1430–51.

Fuhrman, O., McCormick, K., Chen, E. Jiang, H., Shu, D., Mao, S., and Boroditsky, L. (2011), 'How Linguistic and Cultural Forces Shape Conceptions of Time: English and Mandarin Time in 3D', *Cognitive Science* 35, 1305–28.

Kneale, M. (1968/69), 'Eternity and Sempiternity', *Proceedings of the Aristotelian Society*, New Series 69, 223–38.

Lakoff, G. and Johnson, M. (1980), *Metaphors We Live by*, Chicago.

Lakoff, G. and Johnson, M. (1983), *Philosophy in the Flesh*, Chicago.

Long, A. A. and Sedley, D. N. (1987), *The Hellenistic Philosophers*, 2 vols., Cambridge, 1987.

Maass, A., Suitner, C., and Nadhmi, F. (2014), 'What Drives the Spatial Agency Bias? An Italian–Malagasy–Arabic Comparison Study', *Journal of Experimental Psychology: General* 143, 991–6.

McGlone, M. S. and Harding, J. L. (1998), 'Back (or Forward?) to the Future: The role of Perspective in Temporal Language Comprehension', *Journal of Experimental Psychology: Learning, Memory and Cognition* 24, 1211–23.

Miles, L. K., Tan, L., Noble, D., Lumsden, J., and Neil M. (2011). 'Can a Mind Have Two Time Lines? Exploring Space-Time Mapping in Mandarin and English Speakers', *Psychonomic Bulletin and Review* 18, 598–604.

Newton, R. G. (2004), *Galileo's Pendulum: From the Rhythm of Time to the Making of Matter*, Harvard University Press.

Núñez, R. E., Motz, B. A., and Teuscher, U. (2006), 'Time After Time: The Psychological Reality of the Ego- and Time-Reference-Point Distinction in Metaphorical Construals of Time', *Metaphor and Symbol* 21, 133–46.

Núñez, R. E. and Sweetser, E. (2006), 'With the Future Behind Them: Convergent Evidence From Aymara Language and Gesture in the Crosslinguistic Comparison of Spatial Construals of Time', *Cognitive Science* 30, 401–50.

Núñez, R. E. and Cooperrider, K. (2013), 'The Tangle of Space and Time in Human Cognition' (Review), *Trends in Cognitive Sciences* 17 (5), 220–9.

Radden, G. (2003), 'The Metaphor TIME AS SPACE across Languages', in Baumgarten, C. B. N., Motz, M., and Probst, J. (eds.), *Übersetzen, Interkulturelle Kommunikation, Spracherwerb und Sprachvermitlung:—das Leben mit mehreren Sprachen. Festschrift für Juliane House zum 60. Geburtstag. Zeitschrift für Interkulturellen Fremdsprachenunterricht*, Bochum: Aks-verlag, 226–239.

Radden, G. (2011), 'Spatial Time in the West and the East', in Brdar, M., Omazić, M., Pavičić Takač, V., Gradečak-Erdeljić, T., and Buljan, G., (eds.), *Space and Time in Language*, Peter Lang.

Santiago, J., Lupiánèz, J., Pérez, E., and Funes, M. J. (2007), 'Time (also) Flies from Left to Right', *Psychonomic Bulletin & Review* 14, 512–16.

Torralbo, A., Santiago, J., and Lupiáñez, J. (2006), 'Flexible Conceptual Projection of Time onto Spatial Frames of Reference', *Cognitive Science* 30, 745–57.
Walker, E. and Cooperrider, K. (2016), 'The Continuity of Metaphor: Evidence From Temporal Gestures', *Cognitive Science* 40, 481–95.
Young, S. (1939), 'An Athenian Clepsydra', *Hesperia* 8, 274–84.