The Archaeology of Measurement

Comprehending Heaven, Earth and Time in Ancient Societies

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CAMBRIDGE
UNIVERSITY PRESS
2010

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The token system of the ancient Near East: Its role in counting, writing, the economy and cognition

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Figure 3.1. Pictographic tablet from Godin Tepe, Iran, ca. 3100 BC. The account features 33 units of oil. (Courtesy Cuyler Young, Jr.)

This chapter deals with a system of counters – clay tokens – used for over 4,000 years in the prehistoric Near East (7500–3100 BC). Relying on a database of some 8,000 tokens from Turkey, Syria, Jordan, Israel, Iraq and Iran (Schmandt-Besserat 1992, I & II), I discuss the evolution of the token system, the method of counting it implies and how it led to writing and abstract numbers (Butterworth 1999, 29–32; Rogers 2005, 81–84). Lastly, in the light of the token system, I address the relation of counting and measurements to the economy and to cognition.

Tokens and pictographic writing

Before starting my discussion I explain how the Mesopotamian pictographic and cuneiform scripts are critical to understanding the token system (Schmandt-Besserat 1996).

During the first 500 years following its invention about 3200 BC, writing in Mesopotamia was used exclusively for accounting (Cooper 2004, 72). The tablets served a city state administration scrupulously to record entries and expenditures of goods in the temple and palace. The first Mesopotamian script featured two kinds of signs: impressed signs stood for numerals and signs traced with a stylus represented the goods accounted (Figure 3.1). As is explained later, both of these types of signs, impressed and traced, were images or 'pictographs' of small counters, that is, tokens previously used for record keeping. Some of the pictographs can be understood by matching them to the cuneiform signs that derived from them. The pictographs therefore constitute a 'Rosetta Stone' to decipher the age-old token system. For example, the third millennium cuneiform sign for 'oil' can be traced backwards to the fourth millennium pictograph in the shape of an ovoid with a line at the largest diameter. In turn the pictograph can be matched to earlier ovoid tokens with a line around the maximal diameter (Figure 3.2).

Plain tokens

Tokens appeared in the Fertile Crescent about 7500 BC. They are about 1 or 2 cm across, modeled in clay in different shapes, among them cones, spheres, cylinders, disks, tetrahedrons and ovoids (Figure 3.3). At sites such as Mureybet in Syria, the earliest tokens belong to the archaeological layer marking the beginning of agriculture (Mureybet III), showing that counting and accounting first began when survival depended upon cultivating and hoarding staple goods such as barley (Cauvin 1978, 73–74 and 43). By the seventh and until the end of the fourth millennium BC, the token system was used in a vast region of the Near East including present-day Turkey, Syria, Jordan, Israel, Iraq and Iran. During these 4,000 years the tokens showed no change in manufacture, material, shape and size. Among the more frequently used shapes were small and large cones as well as small and large spheres standing for four different units of barley, cylinders representing animals of the flocks and small and large tetrahedrons standing for labour.

Complex tokens

In the middle of the fourth millennium BC, coinciding with cities, state formation, and the development of workshops, the token system grew more complex. The number of shapes of tokens multiplied to include parabolae, rectangles, triangles and some in the form of miniature vessels, tools and furniture (Figure 3.4). Also,

Figure 3.2. Correspondence between cuneiform signs, pictographs and tokens. (Courtesy *Archaeology* **32** [4] 22.)

markings in the form of incised lines proliferated on the face of the counters, bringing the number of token subtypes to over 300. Whereas the earlier plain tokens dealt mostly with products of the farm, such as barley and domesticated animals, the complex Early Bronze Age tokens were concerned with finished products such as bread, oil, honey or perfume; imports such as metal; and manufactured goods such as textiles and garments.

Tokens and counting

The different token shapes used to count various specific commodities bring to mind 'concrete counting', an archaic technique of counting that was still prevalent in the early third millennium BC in Mesopotamia and is still practiced today in various parts of the world (Diakonoff 1983, 88). Concrete counting is characterized by different sets of number words – numerations – to count different items. Sets of words of our own vocabulary, such as 'twin, triplet, quadruplet' or 'solo, duo, trio, quartet' referring to children of a common birth and groupings of musicians, may help explain the concept of concrete counting. Namely, a word like 'solo' fuses together two concepts, 'one' and 'musician', without any possibility of separating them. The same was true for tokens. For example, one ovoid token (Figure 3.5) stood for 'one jar

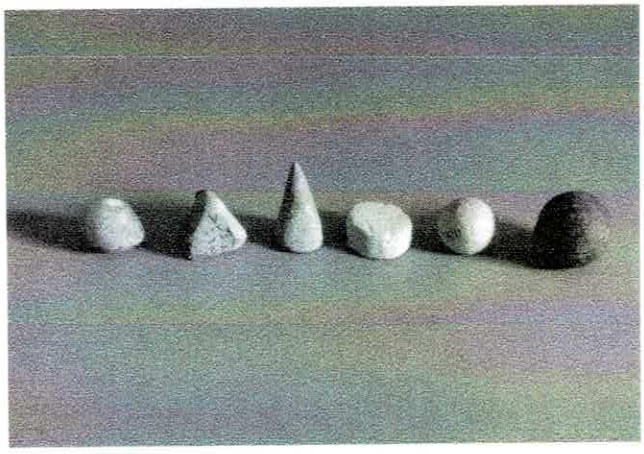

Figure 3.3. Plain tokens from Tepe Gawra, Iraq, ca. 5000 BC. (Courtesy Denise Schmandt-Besserat.)

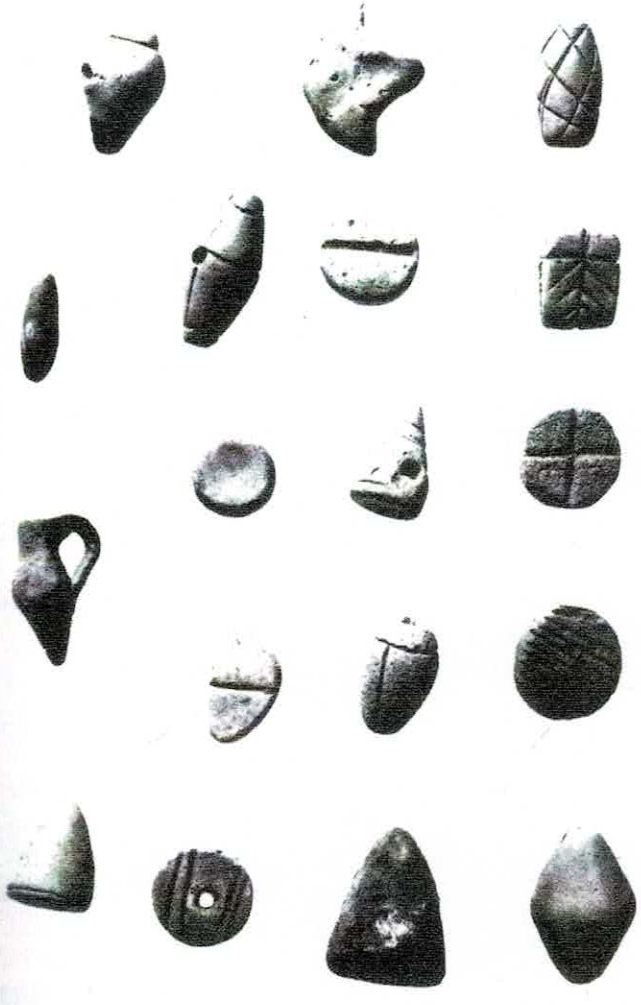

Figure 3.4. Complex tokens from Uruk, Iraq, ca. 3300 BC. (Courtesy Vorderasiatische Museum, Berlin.)

of oil' without the possibility of splitting up the notion of number 'one' with the notion of the object counted, 'jar of oil'. Because these two types of information could not be abstracted from each other, numerosity

Figure 3.5. Ovoid tokens standing for jars of oil, from Girsu, Iraq, ca. 3300 BC. (Courtesy Musée du Louvre, Département des Antiquités Orientales.)

was expressed in one-to-one correspondence. Three jars of oil were represented by three ovoid tokens – literally 'one jar of oil', 'one jar of oil', 'one jar of oil'. The token system illustrates therefore a technique of counting fundamentally different from ours. There were no tokens to express 'one', 'two' and 'three', independently of what was being counted. But instead, as is typical of concrete counting, each token type counted exclusively a specific category of items: ovoids could count only jars of oil and jars of oil could only be counted with ovoids.

The envelopes

About 3500 BC, at the time of state formation, envelopes in the shape of round, hollow balls of clay were invented to store tokens in archives. The clay envelopes were a convenient way to keep together groups of tokens representing a transaction. The envelopes were particularly well suited to the Near Eastern administration because they provided a clay surface where seals could be applied. Indeed, each of the 150 envelopes recovered from Turkey, Syria, Jordan, Iraq and Iran bears the imprints of between one and four different seals that, according to Enrica Fiandra (1979, 36–38), may have represented various levels of the Mesopotamian bureaucracy.

The envelopes prompted a turning point in data processing when accountants pressed the tokens onto the surface of the envelopes to make their shape and number visible from outside after the envelope was sealed. The three-dimensional tokens were reduced to two-dimensional markings – the first signs of writing. Envelopes, such as that of Habuba Kabira (Figure 3.6), showing on the outside the impressions of the seven ovoid tokens (= seven jars of oil) which were found still inside when it was excavated, are precious in providing evidence that complex tokens were still handled in one-to-one correspondence in 3200 BC. The seven ovoid markings pressed on the outside of the envelope shared therefore the same value as that of the seven ovoid tokens inside. Consequently, it may be concluded that concrete counting was still practiced at the time of the invention of writing.

It is interesting to note that from the beginning, the markings on the envelopes were laid out according to a

Figure 3.6. Envelope from Habuba Kabira, ca. 3300 BC, with ovoid impressed markings. (Courtesy Museum für Vor- und Fruegeschichte, Berlin.)

Figure 3.7. Impressed tablet showing three wedges = three small measures of grain and two circular signs = two larger measures of grain, from Godin Tepe, Iran, ca. 3100 BC. (Courtesy Cuyler Young, Jr.)

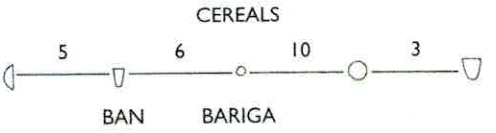

Figure 3.8. Mesopotamian grain measure (Schmandt-Besserat 1992, 151).

standardized format. They were set in straight lines, each line featuring only one kind of sign repeated as many times as needed. For example, a line of circular signs is followed by a line of wedges. The lines of signs were arranged in hierarchical order. Namely, the signs representing the largest units of merchandise were placed on the uppermost line, followed by lines representing lesser units in descending order. It is noteworthy that this strict format was to govern the order and direction of the signs of writing for centuries to come.

The archaic impressed tablets

The envelopes had a relatively short duration of use because, once writing was established, the tokens inside the envelopes were no longer useful. Within three centuries, therefore, the envelopes were replaced by solid balls of clay bearing the impressed markings of tokens. These were the first Mesopotamian impressed tablets.

The accounts presented on the some 250 known Syrian, Mesopotamian and Elamite impressed texts were identical to those on envelopes, showing the continuity between the two types of artifacts (Figure 3.7) (Nissen, Damerow and Englund 1993, 127–128). The signs on the tablets, like the markings on the envelopes, pictured tokens and continued to exclusively feature units of goods. Among the most frequent markings (Figure 3.8), a wedge, standing for a cone token, represented one small unit of barley (probably equivalent to a Mesopotamian *ban* and a modern litre); a circular marking, standing for a sphere token, represented one medium unit of barley (equivalent to the Mesopotamian *bariga*, or a modern bushel); a long wedge standing for a cylinder token represented one domesticated animal. The number of units of goods was still shown in one-to-one correspondence: one wedge = one small unit of barley; two wedges = two small units of barley. Consequently, it can be safely assumed that, by the time of the impressed tablets, the system of counting was still concrete.

The pictographic tablets

Several thousand of the so-called pictographic tablets, dated to about 3100 BC, were excavated in Uruk, Iraq, as well as a small number of sites including Godin Tepe, Iran. The sketched pictographs initiated a new technique of writing that departed from the impressing token; namely, the images of tokens were traced on the tablet with a stylus. The pictographic tablets, however, signified far more than just representing tokens more clearly. The fact that pictographs, such as that standing for 'jar of oil', were never repeated in one-to-one correspondence signals a radical change in counting. The sign for 'jar of oil' was preceded by numerals – signs for 1, 10 and 60 (Figure 3.1) The numerals were indicated by the former signs for measures of barley carrying a new abstract meaning:

- The impressed wedge stood for '1'.
- '10' was an impressed circular marking.
- '60' was a large wedge.

Abstract numbers

Pictography thus marks the extraordinary event when the concept of number was abstracted from that of the item counted. As a result, writing and counting could evolve in separate ways, generating two parallel and complementary sign systems. It was also momentous in overcoming one-to-one correspondence, which had governed counting during the entire token era. This meant a great economy of signs: 33 jars of oil were expressed by seven signs (3 x 10 + 3 x 1 + 'oil') – instead of 33 signs (Figures 3.1 and 3.5)

Of course, the process of abstraction of numbers spun by pictography was to take many steps and many centuries to be fully realized (Justus 1999a). It is clear that, at the pictographic stage, the commodity counted still determined the arithmetic value of numerical signs. For example, when animals were being counted the circular sign signified '10' whereas it was to be read '6' when it referred to measures of grain. Also the relation between measuring units varied with the kind of entities dealt with. For example, the units of grain (*ban, bariga* etc.) followed a sequence of factors: 5, 6, 10, 3 (Figure 3.8), compared to 6, 3, 10, and 6 for the units of area measures (*ikus, eshe*3, *bur* etc.). Moreover, one-to-one correspondence was still clinging on in order to express the number of units and of 10s: 33 jars of oil were expressed by three 10s (three circular signs) and three units (three wedges) (Figure 3.1)

Counting and writing

In the light of the evolution of counting, the origin of writing can be viewed as a by-product of the abstraction of numbers. Namely, the split between the notion of numerosity and that of the item being counted created the necessity for two systems of recording. From this point on, numerals and counted items were recorded by different types of signs: numerals were impressed whereas the signs identifying the counted items were traced. Far more importantly, the two types of signs evolved separately: numerals, like the tokens, remained logographic and continued to be used in one-to-one correspondence. In contrast, writing severed all ties with the tokens by emulating language. New pictographic phonetic signs were created about 3000 BC and by 2700 BC the cuneiform writing emulated the syntax of speech. Writing was no longer confined to accounting real goods. Only then was it able to be applied to topics dealing with intangibles as well as tangibles, concerning the world and beyond.

What is critical is that it is archaeology, rather than philology, that provides us with the means of tracing the origins of writing. Some philologists have taken the view that such a focus on material culture is not warranted, but the evidence for "tokenism", as Michalowski (1993) puts it, is substantial. First, the quantity of data itself is considerable: thousands of tokens, 200 envelopes and 240 impressed tablets. Second, the evidence for the evolution from tokens to writing leaves no gap: each transitional phase is copiously illustrated. Namely, the plain tokens continue through the phase of complex tokens; there are as many as 19 marked envelopes; and the impressed markings go on with no discontinuity through the pictographic stage. Other criticism, based on the small number of complex tokens of particular subtypes (Zimansky 1993, 516), misses the important point that exactly the same types and subtypes have been excavated in such distant sites as Uruk and Girsu in Mesopotamia, Susa and Chogha Mish in Elam and Habuba Kabira and Jebel Aruda in Syria. Whether each site yields 1 token or 100 tokens of each subtype reveals the same significant information: all these fourth millennium city states were administered using the same token system that immediately preceded and led to writing. Such a conclusion is recognized by the vast majority of fourth millennium experts including, to name only a few, Algaze (1993, 15, 39); Englund (2004, 119–122); Frangipane, Ferioli, Fiandra (2007, 22 and 114); Friberg (2007, 282); and Liverani (2006, 54–55)

Tokens and the economy

The prehistoric and protohistoric Near East practiced a redistribution economy that could not have functioned without counting and accounting. Tokens and tablets were necessary to keep track of entries and expenditures in the community warehouses. Vice versa, counting and accounting evolved in order to serve an ever more complex management of the communal goods.

The third millennium cuneiform economic tablets of Girsu make it clear that a major part of the Mesopotamian redistribution economy consisted of 'gifts to the gods'. These offerings in kind, featuring grain, animals, dairy products, fish, jewelry, textile, tools and so on, were supplied by the community on a monthly basis on the occasion of religious festivals (Rosengarten 1960, 251–301). The Girsu tablets also make it clear that the 'gifts to the gods' were strictly regulated. High officials were expected to give one yearling a month, fishermen were required to deliver a given number of baskets of fish and so forth. In other words, in our own vocabulary, the 'gifts to the gods' were taxes.

Proceeding backwards in time, the fourth millennium archaic pictographic tablets functioned in addition as the receipts of temple offerings, which were also strictly regulated. The festival of 'Princely Inanna' at Uruk called for offerings of quantities of dairy products, bread and wool, whereas that of 'Evening Inanna', in a different season, required delivering domesticated animals and tools (Szarzynska 1997, 115–140). Again, the efficient system of pooling together the economic surplus of the society could not have functioned without keeping track of those who had delivered the required dues and those who had not.

Contrary to a common assumption, there is no evidence that tokens or pictographic tablets were ever used in trade. Because early trade was based on barter it required no counting or measurements. The first economic tablet relating to commerce is dated to the Akkadian period in the middle of the third millennium BC. On the other hand, the complex tokens of the fourth millennium BC excavated in the precinct of Inanna at Uruk dealt with the same types of merchandise, in the same quantities as those featured on the pictographic tablets. Consequently, they can safely be considered to have been used to keep a record of temple offerings. In fact, the complex tokens, mostly standing for manufactured goods, may be viewed as marking the period when crafts and workshops started being taxed on their production.

The original function of the token system has to be left to theory. However, because its role, and that of the following pictographic tablets, was consistently and exclusively administrative, it is likely that from the start, tokens were the backbone of the incipient Near Eastern economy of redistribution. The tokens made it possible for the headmen of agricultural communities to control the pooling of communal goods and their redistribution.

In turn the redistribution economy dominated counting and accounting and thereby determined the evolution of the administrative devices. Only a few token shapes were necessary when the required offerings were limited to agricultural products. The forms of tokens multiplied when taxes were levied on industrial products. Finally, concrete counting was supplanted by abstract counting when the large amounts of goods dealt with by a city state administration could no longer be handled by tokens in one-to-one correspondence.

Measurements

It is likely that, in the ancient Near East, measurements were also tied to the levy of 'the gifts to the gods'. Standard measurements were increasingly necessary to regulate and enforce the delivery of specific quantities of goods by an ever larger and diverse community.

The evolution of weight and measures may include the following stages:

1. Casual daily life items such as our present-day 'mug' or 'carafe'.
2. The standardization of these units: the size of containers becomes uniform; the king's foot becomes the standard unit of length for a community.
3. The different units of a same commodity become multiples of one another: a large basket = 10 small baskets, a foot = 12 inches.

The Near Eastern tokens 7500–3500 BC seem to correspond to the first stage, when measures consisted of casual daily life containers. Nothing in the archaeological record suggests that containers such as pottery jars and flasks were standardized.

The beveled-rim bowls common from Syria to Iran during the Uruk period, 3500–3000 BC, may provide the first evidence for the standardization of units of capacity. The crude pottery vessels, thought to serve for the daily distribution of food rations to male and female temple/palace dependents, were molded in two main sizes, which, according to T. W. Beale (1978, 291–292), were each of consistent capacity.

The calibration of units as multiples of one another did not take place before 3100–3000 BC. This is evidenced by a tablet from Jebel Aruda, Syria, ca. 3200 BC, showing 3 large impressed wedges followed by 22 circular signs (= 3 large measures of barley + 22 medium measures of barley). The tablet shows that each type of unit was still counted separately. In other words, the third millennium relation 1 large wedge = 6 circular signs was not yet established (Justus 2004, 24; 1999b, 226; Englund 1998, 118).

One should not forget that the standardization of weights and measures occurred very slowly in the Near East. In the first millennium BC Mesopotamian cities such as Babylon and Assur still had their own 'cubit' to measure length. One of King Darius's greatest achievements was to give some uniformity to the weights and measures within the Persian Empire.

Tokens and cognition

The greatest significance of the token system was probably its impact on human cognition. Tokens were symbols of goods. They introduced new ways of handling

merchandise in abstraction. Accounting with tokens abstracted the data from context. Furthermore, the manipulation of tokens using patterning, such as columns and lines, helped to abstract data such as entries and expenditures, the relative value of products and finally the abstraction of numbers.

With ovoid tokens, jars of oil could be counted in abstraction. It did not matter whether the quantities of oil were already produced or planned for the future, their location in storage or in transit, whether they were owned or owed.

With the use of patterning or the presentation of data in particular configuration the many variables of a large budget could be easily abstracted. The tokens of multiple shapes could be arranged in columns abstracting the types of merchandise, entries, expenditures, surplus or debts, donors or recipients.

The tokens also provided strategies by which to abstract the relative value of merchandize. Tokens of the same kind could be organized in lines. These lines could be organized hierachically with the larger units above the lesser ones (presaging the layout of markings on the envelopes and tablets).

Because they were small objects, easy to manipulate, tokens facilitated counting. They made it easy to add, subtract, multiply and divide by manually moving and removing counters. In turn, the visualization of two tokens added to two tokens, and three tokens to three tokens, and so on, no doubt contributed to the conceptualization of abstract numbers (Justus 1999b, 56, 64; Hoyrup 1994, 70).

Conclusion

In much the same way that geological and archaeological evidence disproves the notion that the world was created in a week, it also gives the lie to the notion that writing was created in a day (*contra* Michalowski 1993, 998). It took millions of years to shape the world, and writing emerged from an evolution of over four millennia, starting when the Near Eastern redistribution economy gave rise to a system of counting, and accounting, to control the production of real goods. These tokens, created in an oral world when information was exchanged face to face, by word of mouth, revolutionized data communication by being extra-somatic. The tokens made it possible to visualize and manipulate numerosity, and as a result, they were instrumental in the evolution from concrete to abstract counting and were responsible for the evolution of record keeping from three-dimensional counters to writing.

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