MANUFACTURE AND MEASUREMENT

Counting, Measuring and Recording Craft Items in Early Aegean Societies

ATHENS 2001
DIFFUSION DE BOCCARD - 11, RUE DE MEDICIS, 75006 PARIS
Cover illustration: Selection of items recorded on various Linear B tablets
(design by M. Zacharioudakis)
Anna Michailidou (ed.)

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ΜΕΛΕΤΗΜΑΤΑ

33
Anna Michailidou (ed.)

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Craft Items in Early Aegean Societies

Edited with the assistance of
Pigi Kalogerakou & Katerina Voutsa

ATHENS 2001
Dedicated to the memory of Manolis Andronicos

By those of the authors
Who were his students
And by the others
Who wish they had been
Published thanks to the generosity of

COMMERCIAL BANK OF GREECE

and

EFG Eurobank Ergasias
FOREWORD

The publication of each new volume of the ΜΕΛΕΤΗΜΑΤΑ series is an event which gives great pleasure. But the publication of this new volume edited by Anna Michailidou and dedicated to manufacture and measurement in early Aegean societies has a special significance. It is the first in the series to deal with second millennium archaeology and history, and it will soon be followed by others, opening a new and promising field of research for our Centre.

Early Aegean and, more particularly, Mycenaean Studies, after a rapid expansion in the third quarter of the last century, mainly due to the decipherment of the Linear B script, experienced a long period of stagnation before a new blossoming in very recent years. This we owe to two independent but converging developments: on the one hand the increase of the corpus of texts, thanks to the patient joining of fragmentary documents already known as well as to the discovery of new archives in unsuspected parts of the Mycenaean world; and on the other hand the application of novel approaches, inspired by new trends in archaeology, to their study.

Old passions, particularly passions of youth, die hard and a little fresh air is enough to rekindle the flame. Long before the stones of Macedonia, even before structural analysis of Spartan cults, my first scholarly infatuation was with the Mycenaean world. I was fortunate to be initiated to it by Michel Lejeune and to discover it in the company of my life-long friend Olivier Masson at the IVe Section of the École Pratique des Hautes Études. Since then I have followed with enthusiasm the progress of Mycenaean studies and always regretted that they are not given the importance they deserve in Greece. Recently, parallel discoveries and scholarly breakthroughs on both sides of the Aegean sea have revealed to us in its complexity and richness the political map of the Late Bronze Age. Hieroglyphic and cuneiform documents allow us to recover the political history and the historical geography of that period, while the ethnics figuring in the Linear B tablets indicate, be it indirectly, trade routes, ports of call and points of contact between Achaean Greece and Hittite Asia Minor. Such high-level history, passionately interesting though it is, would remain to a large extent unexplained, not to say incomprehensible, without the study of the humbler activities of the craftsmen who produced, measured, weighed and thus prepared for commercialisation the artefacts which followed the great trade-routes and were exchanged at Knossos, Thebes, Miletos, Ephesos or other important centres of the Aegean. To these activities is the present volume dedicated, and I am grateful to Anna Michailidou and all those who contributed to it for having conceived, planned, financed and prepared it for us to read and learn from.

Miltiades B. Hatzopoulos
Director of the Centre for Greek and Roman Antiquity
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INTRODUCTION

Anna Michailidou

The writing of a book calls for a central idea that will provide the author with the necessary inspiration. While Iris Tzachili was writing in her doctoral dissertation about the different quantities of wool required for each kind of textile, I was striving to understand precisely what it was that people measured with the balance weights found in the prehistoric town at Akrotiri on Thera. Our discussions led to the central idea for this book, the connection between prehistoric technology and accounting. And, in this, we were also concerned with the role of writing, not only because in its absence we would not have even the limited knowledge we do possess of our subject, but because the way in which the result of a measurement or a count was recorded by the inhabitants of the early societies of the Aegean and the surrounding area affords a clue to the economic context of the three actions involved. More specifically: for which craft-industrial products, or the raw materials used in them, were records kept, by whom, how and why? The central idea acts as a stimulus to investigation, which follows routes sometimes leading to remote areas. The object of the investigation - selected archaeological finds and written testimonia - leads the inquiry into different cultures. Experience in research warns us of the dangers posed by incompletely preserved material or textual evidence, and by our inevitable subjectivity.

The writing of a book also requires an occasion: the present volume is the result of a research project submitted, on behalf of the Centre for Greek and Roman Antiquity, to the General Secretariat for Research and Technology for the Programme of Support of Young Researchers (ITENEA). The proposal was approved in return for an undertaking to design a database relating to weighing activity attested in the Linear B tablets, and at the same time to train three young researchers in this field of knowledge. As a true archaeologist of the old school, however, I am drawn more to the printed page than to the screen and I therefore suggested to my colleagues in the project that a book should be published on the subject of our research.

These colleagues - old friends from the work group of the excavations at Akrotiri, Thera \(^3\) and young postgraduate students at the University of Athens \(^4\) - took up the challenge. I suggested

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1 For writing, according to Thoth, the Egyptian god who invented it, is 'an elixir of memory and wisdom', while according to Socrates, it is 'an elixir not of memory but of reminding' (Plato, *Phaedrus*, 274-275).
2 Manufacture, accounting and writing, the sequence of which varied: measurement of the raw material before the act of manufacture, measurement of the finished product, record of the former and/or latter measurement.
3 Dr I. Tzachili, Dr K. Trantalidou and Dr A. Sarpaki.
4 The colleagues who worked on the database for the programme, D. Kriga, A. Dialismas and K. Voutsa, were encouraged to make their first appearance as writers on subjects related to the dissertations on which they were working. The subject chosen by the first of them - the find places of the tablets - has not been included in this volume since it has now been dealt with in three articles of the journal *Minos* (1996-97). The subjects treated by the other two young researchers are meant to complement the concerns discussed in the other chapters, which are of a broader content.
subjects, discussion followed, after which the chapters were defined according to individual expertise, and then each author set off along his or her path. Other scholars, whom I knew to be working in related fields, agreed to contribute to the volume. The chapters of the book correspond with only some aspects of the central idea, since each contributor was guided by his or her personal research. I did not consider it desirable to prescribe from the outset regulations relating to homogeneity and length, but felt it preferable to leave the contributors free to express what they themselves adjudged could be said, from the point of view of their own specialities. This means that the editor of the volume would not interfere with the views expressed; and this explains why, despite the fact that the original idea for the book derived from the Mycenaean tablets, the articles extend to other horizons, both chronological and geographical, either because this was rendered necessary by the methodology involved in the specific piece of research or because it was dictated by the nature of the material and the problems arising from it.

Accounting is related to the creation, storage, circulation and distribution of products. As is apparent from the title, it was decided to concentrate on craft-industrial production; the extensive agricultural production will have to form the subject of a separate volume. Generally speaking, there is a difference between the two in the method of accounting, a unit of weight being predominantly used for craft-industrial goods (such as wool and objects of metal) and a unit of volume for agricultural products (grain, wine, oil, figs, etc.). For the numerical system that lies at the bottom of every metrical system, the foundations in the investigation of the south Aegean evidence were laid by Evans (1935) even before the decipherment of the Mycenaean script, while Bennett’s work (1950) on Bookkeeping in the Linear A and B documents remains a classic. After Ventris and Chadwick (1956), the article by Sacconi (1971) associated the specific segni di misura in the Linear B script with particular products, while Killen’s article (1962) provided scholarship with the special unit LANA, used to weigh wool. For the metrical system of weight, in particular, the work by Evans (1906), Caskey (1969) and Parise (1964) came first and the crowning achievement of metrological research by Petruso followed (1978 onwards): these studies mark a shift in interest from the evidence of the documents to the mathematical information embodied in the instruments of measuring themselves (the balance weights). Chadwick (1976) completed the circle by converting the values of stone balance weights from Knossos to multiples of selected Linear B signs/metrograms. Cherry (1980, 1983) proposed the statistical tool for the investigation of Aegean metrology. Renfrew (1983) included the designing of a metrical system amongst the objects of study of so-called Cognitive Archaeology, or Archaeology of Mind. It is thus the human mind for which we are seeking behind the evidence relating to accounting and writing.

The division of the volume into two parts was dictated by the content of the chapters submitted, since the basic aim was to exploit the special expertise of the particular scholars rather than to ask them to accommodate themselves to a predetermined general scheme; for the same reason, the Aegean remains the main area of investigation. The common link between all the chapters is the search for quantity, preferably in the manufacturing process associated with a technological product, whether it is directly recorded or can be calculated on the basis of later evidence and data drawn from outside the Aegean. The first part of the book deals selectively...
with some stages in the evolution of prehistoric or proto-historic accounting and with its interlocking relationship with writing. The second part is concerned rather to associate the two activities with the production of particular goods.

I. For the Egyptians, mathematics and writing were not invented by a mere mortal, but by the god Thoth. The modern archaeologist, however, believes in the abilities of the human mind, so at the beginning of her chapter, Christina Marangou sets out in search of the mind of Neolithic man. In her semiotic study of ‘Artefacts as signs and signs on artefacts’ she assembles the probable evidence so far for counting and writing, mainly from Neolithic sites in northern Greece. Since the views on the role played by tokens in the Near East are well-known (as, too, is the criticism to which they have been subjected), she sets the material under investigation in the broadest possible context, referring to the parameters that potentially influence its operation. It having been established that in the Neolithic period there was the necessity and also the ability, to devise a system of signs for special ends, their use for other purposes, like counting, cannot be ruled out.

For the leap (or evolution?) to an accounting script, Artemis Karnava cites the example of the documents written in the Cretan Hieroglyphic script. Ideograms (or logograms) for products are followed by numbers, both integers and fractions. The existence of a fraction confirms that the quantity of the good denoted by the ideogram was measured (in contrast with the integers, which may only indicate the simple counting of items). The devising of a metrical system (for length, volume or weight) presupposes the concept of fractions. Research into the Cretan Hieroglyphic script is at a very interesting stage; this script antedates and is partly contemporary with Linear A, the fractions in which have been the subject of exhaustive (and conflicting) studies. What is certain is that by the time of Linear B, fractional numbers had been replaced by whole numbers of fractional quantities, themselves expressed by individual signs that formed the units of the metrical systems.

The content of the final chapter of part one deals with the relationship between metrology and writing. In it, Anna Michailidou discusses weights or balance weights that are inscribed with Linear A signs. It is noted that there are very few instances of deliberate or officially sanctioned inscriptions on balance weights in the Aegean, in comparison with the practices of neighbouring countries in the eastern Mediterranean, with a simple sign, or no sign at all, being much more common. The view that certain ‘practical processes’ were retained in the context of ‘cognitive inventions’ is further supported by the survival of methods of standard accounting attested by specific weight units for particular goods (gold, wool, saffron). The term ‘concrete weighing’ is proposed, and it is suggested that the reason for this phenomenon is to be sought principally in the mode of production of the goods in question, which affects their exchange value.

II. The second part of the book is devoted to the circumstances of production, circulation and accounting associated with craft-industrial products made of metal, wool, linen and other animal or vegetal processed materials, with the focus on the methods by which they were recorded.

In the first chapter on metals, the subject of the study by Anna Michailidou is quantity, as it was circulated (in the standardised form of the ingot, as waste material or rejected artefacts destined for recycling, or as finished product to which the value of the work is added), as it was recorded in the archives, and as it is documented by measuring the weight of archaeological finds. Tables of artefacts and fragments of texts are appended by the author. It is noted that the

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8 Hence the subtitle of the chapter in question.
9 Whereas ‘concrete counting’, as a preliminary stage of counting, ended up in the abstract numbers, ‘concrete weighing’ seems to reappear, also in connection with the general (abstract) scale applied to other goods.
Mycenaean tablets do not contain the variety of records to be found in the tablets of the Orient: in the latter the weight of the metal is recorded at every stage of the metal-working process, when the production is checked, and when it is distributed at all social levels. Nonetheless, a homogeneous picture emerges of the mechanisms for the circulation of metals in the pre-coinage societies of the eastern Mediterranean, and it becomes evident that everywhere the central authority felt it necessary to take steps to control their circulation. The important feature here is that, alongside the intervention of the ‘palace’, it can be seen that the exchange value of the metal could be exploited at the practical, everyday level and in an urban environment.

In the second chapter, Alkis Dialismas returns to the Mycenaean tablets—with an extensive and occasionally repetitive bibliography on the subject of metals—in order to isolate the finished products and give a clear sketch of the numbers produced or at least recorded (with representative tables drawn from the relevant database of our Institute). In order to furnish a fuller context for some of the wider subjects investigated in the present volume, the objects are classified in three categories: those that are thought certainly to be of metal, either because they are accompanied by a qualifying symbol for metal, or because the use of metal for their construction is an inevitable conclusion from the function of the objects in question; objects that might be of metal, but which are not accompanied by any indication to this effect; and objects whose construction material included metal. Attention is drawn to the mature stage of the research to date, which makes it possible to draw comparisons—in terms of quantity as well as of kind—with the archaeological record, both in the sphere of production and in that of consumption.

Amidst this deluge of raw materials and finished products, a useful contribution is made by Katerina Voutsas on the human capital recorded in the Mycenaean tablets. Her study in the field of personal and craft names—a domain already at an advanced stage of research—is prefixed by an attempt to establish an overall picture of the productive process: from the moment the raw material arrives—in whatever way—in the hands of the craftsmen to the moment the finished products are delivered. The evidence is classified under three categories. For weaving and, to a lesser extent, the production of aromatic oils, leather working and the manufacture of chariots, all three factors can be established: the raw material, the craftsman, and the finished product. In the case of metal-working, the craftsman is recorded in the context of his relationship either with the raw material or with the finished product (so two factors each time of recording). The third category (one factor only) includes craftsmen recorded in isolation, who can only be identified as such on the basis of their professional name; tables are appended linking the term of the relevant trade with raw material or finished product.

There follow two chapters on textiles by Iris Tzachili. The first was read at a 1987 Aegean conference that was never published; at that time research was oriented mainly towards the wool and less to the finished product. This chapter deals with the circulation of textiles, and poses questions such as what was the relationship of the trade of textiles to the creation of a surplus in palace society, to what regions were Minoan textiles probably despatched, and with what kinds of goods were they exchanged in return. She notes that the most common archaeological evidence for weaving—spindlewhorls and loomweights—are most often found at ports in areas that do not always fall under the immediate palace authority; invoking also the testimony of the Mycenaean tablets, she suggests that the palace attempted to intervene in areas that had previously functioned independently of it.

Her next chapter concentrates on the quantities of textiles recorded in the Mycenaean archives at Knossos, with an attempt to arrive at a historical assessment of the data. This is preceded by a theoretical introduction on the meaning of quantity, in which she notes that the calculation of quantity is not to be seen as an absolute, but was almost always a comparative act; quantities are investigated mainly to establish the place occupied by a particular category of
goods within the general productive system of a settlement. There follows a classification by ideogram of the textiles counted in the KN I, Lc, Ld and Le series, with special reference to textiles discussed as gifts for foreigners (?) or destined for elite recipients. After counting the number of textiles recorded, the author poses the crucial question: are 5,700 pieces many or few? This confirms the necessity of the theoretical concerns set out at the beginning of the chapter.

Our attention is turned to raw materials derived from plants by Anaya Sarpaki, who adds the perspective of the archaeologist-archaeobotanist to the varied and extensive bibliography on Mycenaean tablets relating to perfumes and spices. She deals with all plants that were used as perfumes, spices, or dyeing materials, drawing upon the archives published so far. In an attempt to establish the possible economic and social implications of the investigation, she notes the recording in Pylos and Mycenae of aromatic herbs from regions outside the Aegean. As a result, she concludes that at the two sites just mentioned these luxury goods were consumed, to a greater extent than at Knossos, which, on the basis of the corresponding archives she describes as mainly a production centre.

Reference to textiles in previous chapters leads on to the subject of raw products derived from animals—mainly wool—which takes us to the question of the processing of animal products, dealt with at length by Katerina Trantalidou in the following chapter. Her interest is concentrated on leather, which has attracted far less attention from scholarship than wool, despite the fact that archaeological finds (both small finds themselves and the iconography), ethnographic evidence and texts from the Orient demonstrate the importance of its role in production and circulation, and consequently in accounting (normally involving counting, though there are some cases of the weight of leather being recorded). Using evidence drawn from later literary sources, and appending tables illuminating the role played by quantity in early modern times, she concludes that this review of the secondary products demonstrates that the same materials, used over millennia, were counted, weighed or had their volume measured. In the case of the palace economy, in particular, the tendency was primarily to control the production of wool, which was used for clothing, and only secondarily for the palace to concern itself with other animal products which were used in defensive or offensive weapons and armour production.

The second part of the volume is followed by an Appendix giving details of the database, set out by Alkis Dialismas, with examples of tables relevant to the subjects of the chapters in this volume.

The final aim of this book is not to prove new ideas or to further document old ones; it is meant to give the archaeologist's view of the sources available and to combine in one volume crucial topics related to the subject of counting, measuring and recording craft items in pre-coinage societies. The opening of each chapter is so designed as to give emphasis to the diachronic role of mathematics and manufacturing technologies; this is why the photographs used to this end do not provide archaeological documentation but are deliberately chosen to illustrate related subjects from the life and art of much later periods.

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**Acknowledgements**

This book is the final product of a research project undertaken as part of the Study of Prehistoric Technology and Economy, in the Research Programme for Southern Greece, of the Institute for Greek and Roman Antiquity. I wish to express my thanks to the Director of the Institute, Dr M.B. Hatzopoulos, for his support in the publication of the book, and to Dr A. Rizakis and Dr Ch. Papageorgiadou, for various discussions in a friendly environment. The technical assistance provided by the secretaries, Mrs N. Issangelea and Mrs E. Soulioti, the librarian Mrs Rea Micha and the computer system administrators Mr E. Frangopoulos and Mr K. Tremountainis, has been of great help.

I would like to express my thanks to all the authors of the volume for their participation, and my gratitude to Dr Pigi Kalogerakou and Mrs K. Voutsas for their invaluable contribution to the editorial process. Parts of the discussions at this book have been based on previous research in the libraries of the Istituto Archeologico Germanico (Rome), the Deutsches Archäologisches Institut (Berlin), the Institut für Ur- und Frühgeschichte in Heidelberg, the Griffith Institute in Oxford and last but not least the University Library of Crete at Rethymnon; I am indebted to the directors of the above Institutes for their help.

We all owe a great deal to the special abilities of the translators Mrs A. Doumas (two chapters) and Dr D. Hardy (five chapters and the Introduction). The idea for the cover of the book was of Dr Ch. Boulitis and the design is by Mr M. Zacharioudakis.

Finally, the publication of this book would not have been possible without the economic support by the Eurobank and the Commercial Bank of Greece.
PART I

COUNTING AND MEASURING IN PREHISTORY
A modern abacus, with a long history behind it as an instrument for calculating. According to Dilke (Mathematics and Measurement, 1987, 22) its name is derived from the Old Semitic *abaq* (sand), and originally took the form of grooves drawn in sand, along which pebbles were moved.
EVIDENCE FOR COUNTING AND RECORDING IN THE NEOLITHIC?
ARTEFACTS AS SIGNS AND SIGNS ON ARTEFACTS

Christina Marangou

Both arithmetic and recording rely on semiotic systems, necessary for storing information. Search for indications of such human operations in prehistoric periods, before the existence of deciphered texts, can only be based on material culture and on the study of human cognition and behaviour. The archaeological record in the Near East and Europe comprises three-dimensional artefacts of unknown function, as well as two-dimensional marks on various artefacts, which have both been interpreted as the materialisation of signs belonging to past reckoning and recording systems in a concrete form. This hypothesis is considered here for the evidence of the Greek Neolithic, in the light of previous studies on data from other areas.

I. THEORETICAL BACKGROUND

1. Signs and signs

The word ‘sign’ is used here with two different meanings. The first one consists of a ‘mark, symbol, or device used to represent something or distinguish the object on which it is put’ (sign). The second one refers to a ‘basic element of communication, ...consisting of two indivisible elements, the relation between which is arbitrary (signifiant and signifié), and which derives its meaning only from its relationship to other signs within the same sign-system’ (sign). According to Molino, the most accurate definition of the sign, is something which stands for something else (stat aliquid pro aliquo according to the Scholastics). Peirce considers that a sign is something that means something to somebody, that it creates in this person’s mind an equivalent or a more developed sign, the ‘interprétant’ of the first sign. An object can be represented or referred to through ‘interprétants’ of the original sign, in infinite cross-reference.

Molino distinguishes a semiology of communication (the sign is an instrument of human communication) and a semiology of representation (the sign is a substitute whose function is primarily cognitive). He agrees with Leroi-Gourhan that man builds concrete tools and symbols, both relying on the same fundamental equipment of the mind. Language and tool are both expressions of the same property of humankind. Both human memory and tool are exteriorised

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1 Brown 1993, 2858, ‘sign’ 2a, 2e.
2 Molino 1992, 16.
3 Something which stands for or represents something else is called a symbol (see further) by Renfrew (1994, 5).
5 Molino 1992, 16.
6 Molino 1992, 16.
7 Leroi-Gourhan 1964, 162-163; Molino 1992, 16.
and contained in the (ethnic) collectivity.\textsuperscript{8} The sign, then, exists materially and can be analysed as an object.\textsuperscript{9}

According to Peirce,\textsuperscript{10} signs are classified into icons, indices and symbols. Iconic signs are those linked by resemblance to the things they are signs of. Indexical (indicative) signs are constrained in their form by what they indicate. Symbolic signs stand in an arbitrary relation to what they represent; they need neither resemble nor be constrained in their form by those things.\textsuperscript{11} This shows the difficulty of assigning a material object or a mark to one of these categories. It would mean accepting that they were representing more or less accurately other things (they would be icons) or that they may refer to them by being affected by these objects (by having some common quality) (they would be indices) or without any perceivable relation to the latter (they would be symbols).

A symbol is ‘a thing conventionally regarded as representing, typifying or recalling something else by possessing analogous qualities or by association in fact or thought; especially a material object representing an abstract concept or quality’.\textsuperscript{12} Or a symbol is defined as ‘that which, by custom or convention, represents something else’.\textsuperscript{13} Because the relationship of representing is only referential, one (symbolic) sign can, in principle, be ‘substituted for another with no loss of functional utility, provided that all relevant sign users are aware of the substitution’.\textsuperscript{14}

The sign has symbolic function in particular types of behaviour, such as language, script, calculation, etc., which allow representation through signs or images.\textsuperscript{15} The relationship between these forms of expression and what they refer to, as well as the nature of code-making are arbitrary.\textsuperscript{16} The existence of an object of reference shows the conceptual level of the substitution during code-making; anyone who understands the reference understands the concept.\textsuperscript{17}

As the tool represents distance from the object, the symbol represents distance from reality. Since there is mediation and distance, there is the possibility of a projection toward the past (memory) and toward the future (daydreaming, imagination, technical, artistic, and scientific creation).\textsuperscript{18}

Renfrew\textsuperscript{19} has recently summed up the different uses of sign systems by humans, referring to them rather as symbol systems. His approach considers, more generally, ‘cognitive’ archaeology as the ‘study of past ways of thought as inferred from material remains’. It studies the specially human ability to construct and use symbols, as well as the ways in which symbols have been used in several categories of human behaviour. These include design (purposive behaviour), planning, measurement, social relations, the supernatural, and the representation of reality.\textsuperscript{20}

\textsuperscript{8} Leroi-Gourhan 1965, 64.
\textsuperscript{9} Molino 1992, 17.
\textsuperscript{10} See, for example, Greenlee 1973, 70ff.
\textsuperscript{12} Brown 1993, 3183, ‘symbol’.
\textsuperscript{13} Noble & Davidson 1996, 61.
\textsuperscript{14} Noble & Davidson 1996, 63.
\textsuperscript{15} Molino 1992, 17 with references.
\textsuperscript{16} Noble & Davidson 1996, 58, 60.
\textsuperscript{17} Noble & Davidson 1996, 61.
\textsuperscript{18} Molino 1992, 19.
\textsuperscript{19} Renfrew 1994.
\textsuperscript{20} Renfrew 1994, 3, 5, 6.
1.2. Memory and cognitive devices

Oral societies use their own mnemonic devices, but they may also have specific graphic (not written) complements. D'Errico has stressed the importance of the emergence, during a major stage of the evolution of human cognition, of symbolic forms of behaviour, resulting in the ability to preserve and use information stored away from the human body.

Sign systems, for instance art, counting, measurement, story-telling and writing, constitute reinforcing mechanisms which increase the length of time that information may be kept in short-term memory (which has a very small capacity) and accessed and brought from long-term into short-term memory.

Sign systems and corresponding cognitive devices for recording and processing large quantities of information, impossible to retain by memory, can be used on several occasions, such as the above-cited examples. Another extreme case is navigation out of sight of land. Besides an understanding of the principles of boat building and sailing, knowledge of the waters, sky and wind were necessary to prehistoric mariners. The latter lacked precision instruments to guide them in directional orientation, although they had to conceptualise and calculate time, in the case of tides, and measure distances and speed. Instruction of traditional seafaring in Pacific islands still uses mnemonic devices for the memorisation of sea routes, directions, stars positions, currents and winds and we can presume that some sort of cognitive devices would have been necessary also in the prehistoric Mediterranean.

Measurement requires actions in which devices for measuring and units of measure are often involved, including weights, measuring rods, etc. Thus, some artefacts not only reflect cognition but also intentionally represent mental content; they have meaning; they are intended to be read. Material representations, physical traces of cognitive devices, such as dials for time, direction and distance, are not, though, merely mental aids; they may include public display. This social aspect seems to be often, if not always, interwoven with the expression of the mental ability and erudition of some individuals, and, more generally, with knowledge and lore, including their teaching and transmission, of which the most obvious example would be initiation.

1.3. Elementary forms of counting and recording

The simplest method of reckoning is concrete counting, based on a one-to-one correspondence by comparing two sets of beings or objects, by bijection. Different means may be used: shells, bones, grains, sticks, pebbles. They were possibly used very early in prehistory and are still used today: for example, some Iraqi shepherds keep track of their flocks with

21 Hagège 1985, 84-86.
23 D'Errico 1998, 19 with references.
24 Zubrow 1994, 189.
25 Frake 1994, 123, 124, 128.
26 Renfrew 1994, 6, 7.
27 Frake 1994, 119.
30 Ifrah 1994, 43.
pebbles. These piles of stones and other objects manipulated for arithmetic operations led much later to the appearance of calculating instruments.

This method cannot indicate what item was counted and cannot count more than one category at a time. Nevertheless, it permits the attainment of several numbers, without naming or knowing the quantities. Use of symbols which stand for concrete objects and convey information about their number, and which cannot dissociate numbers from the items counted, does not assume the concept of number and abstract counting. These proto-arithmetical techniques rather indicate the ability to establish correspondences between symbols and counted objects, that is, concrete counting.

Yet, handling large numbers is difficult for ordinary minds. Direct visual perception of numbers has its limits. In oral societies, multiplication being in effect non-existent, addition is based on counting a set of objects or by visual direct representation. Counting one by one may be replaced by a cognitive process called subitizing, that is, apprehending without counting sets of six or fewer elements, a limit fixed by the structural characteristics of the human brain. This can result in the ‘base’ principle of a system of numbering, when a certain number of units is replaced by a higher unit (cf. for example the sexagesimal system of the ancient Near East). Grouping objects in order to count them is an important progress, the process being done by ordering them in series, and shows that the number sequence is unlimited.

II. Evidence about Prehistoric Counting/Recording Sign Systems?

II.1. Palaeolithic and Mesolithic

One can easily imagine that similar simple mnemotechnic devices were invented independently and used in different times and places. It is not surprising, then, that some series of prehistoric artefacts bearing sets of elements have been interpreted as counting or recording devices, such as the universal bone or wood tally sticks, used till recently, which are carved, scratched or cut. The simplest ones bear rows of similar notches. A single kind of mark –notch–
shows that tallies could handle only one type of data at a time;\textsuperscript{46} only quantities of objects or beings are indicated, not their nature.\textsuperscript{47} These notches could not be abstract numerals, since the numbers they are supposed to have represented would be tied to the objects numbered.\textsuperscript{48} Knots used as numerals in Peru attest a comparable method, but there they were used for state records (quipus).\textsuperscript{49} The rows of notches on tallies may also be organised in separate groups, requiring variation\textsuperscript{50} in marks.\textsuperscript{51}

Groupings also mean rhythm, a concept that is inherent in man.\textsuperscript{52} Regular rhythms in the natural world can be observed about stars, seasons and days, walking and heartbeat.\textsuperscript{53} It has accordingly been argued that the first item to be counted was time. Measuring time in fact involves many repeated, sequential actions, which, when recorded, often display periodicities related to those of the sun and moon: the number of days, the lunar month and solar year.\textsuperscript{54}

Thus the next step was attributing rhythmic sequences of marks incised on tallies to calendar notation. This was the main interpretation by Marshack\textsuperscript{55} of marks on a series of Palaeolithic bone and ivory objects\textsuperscript{56} attested since the end of the Mousterian. Counting time would then, according to Schmandt-Besserat,\textsuperscript{57} permit dispersed communities to gather at intervals on special occasions. Others have interpreted the same marks as recording hunted animals.\textsuperscript{58} Leroi-Gourhan\textsuperscript{59} considered it more probable that they would be aids for rhythmic incantations and recitations and correspond to the rhythm of speech ('dispositif rythmique de caractère incantatoire ou déclamatoire'): a function similar to that of the Australian churinga, small plaques engraved with abstract patterns related to a mythical content.

According to Couraud,\textsuperscript{60} the Mesolithic Azilian (11000-9000 BP) painted and/or engraved pebbles ('galets aziliens') show a continuity of patterns since the Palaeolithic period, and exhibit a predilection for certain clusters of numbers. The lunar calendar argument would be debatable for the larger numbers, but seems impossible for the frequent small ones; the latter may have had various functions. Yet, groups of pebbles bearing small numbers may also have been considered

\textsuperscript{46} Noble & Davidson 1996, 223.
\textsuperscript{47} Ifrah 1994, 160.
\textsuperscript{48} Menninger 1969, 247. See note 35.
\textsuperscript{49} Menninger 1969, 253; Ifrah 1994, 169ff.
\textsuperscript{50} Menninger 1969, 240.
\textsuperscript{51} It has been argued that bar-and-dot numerals, among the earliest recognisable Mesoamerican written signs were probably much older than writing, because they are structured as simple tallies (Justeson 1986, 440, fig. 2a), representing bars and dots.
\textsuperscript{52} Leroi-Gourhan 1964, 265; 1965, 82.
\textsuperscript{53} Leroi-Gourhan 1965, 142-144.
\textsuperscript{54} Renfrew 1994, 7.
\textsuperscript{56} Objections as to the identification of these marks as intentional have been expressed by Noble & Davidson (1996, 223), who argue that marks in bone occur thousands of years before the appearance of modern human morphology and before the signs or symbols. Besides, they might be an unintended by-product of the action of cutting with sharp-edged stone flakes on flesh-bearing bone. They show 'increasing control of motor sequences, but would not prove that those leaving the marks noticed them'.
\textsuperscript{57} Schmandt-Besserat 1996, 101.
\textsuperscript{58} References in D’Errico 1998, 20.
\textsuperscript{59} Leroi-Gourhan 1964, 263.
\textsuperscript{60} Couraud 1985, 98-110.
as sets. The same author admits the notation of some unknown 'cycles' at the end of the Palaeolithic and the last glaciation.

Microscopic examination of the engraved stone and bone Mesolithic artefacts and experimentation persuaded D'Errico that the engravings had been made without any slow accumulation. This led him to the conclusion that the Azilian engravings could not be calendars or marks of hunting, but that they were rather made in a quick succession of gestures with the same tool and at the same time. They would not be the bearers of a specific information (word, phoneme etc.), since they are not distinguished individually. Some of them could nevertheless be schematised human or animal figures. The engravings do not reflect a consequence of climatic changes, but rather resulted from a tendency towards schematisation.

D'Errico further admits the existence, since the Palaeolithic, of 'artificial memory systems' (AMSs) ('systèmes artificiels à mémoire'). Evidence about their existence in the Lower and Middle Palaeolithic is limited and controversial, but it is certain in the Upper Palaeolithic of Europe. He accepts that several factors are important for the elaboration of a code for such systems: morphology, spatial distribution, number and temporal accumulation of the elements. He argues that, at the end of Upper Palaeolithic, marks and sets become more numerous, while marking techniques producing many marks on a restricted surface are used, and visual perception is more systematically practised for retrieving information. The codes become more complex, with hierarchical organisation of information and the use of formally differentiated marks.

II.2. Neolithic

Simple mnemotechnic means were sufficient for a very long period, but accumulation of information resulted at a certain point in the inability of the human memory to manage it and external storage became necessary. In a discussion about cognitive phases in human evolution, Renfrew proposes a distinct phase of 'external symbolic storage employing symbolic material culture, characteristic of early agrarian societies with permanent settlements, monuments and valuables'. This phase would follow the transition to food production (the 'Neolithic revolution') and precede the transition to the development of writing (somehow related to the 'urban revolution').

It is in this general context that some series of Neolithic finds from Greece and its neighbouring areas, notably Near East and south-eastern Europe are considered. They consist of:
- small objects of unknown function, and
- artefacts, including examples of recognisable categories, such as tools, vases or miniature objects, which bear incised signs (marks), in addition to or independently of decoration.

In the absence of any proof of function, the study of the material objects of the first category may deal with interpretative hypotheses and consider them as signs, belonging to one or more

61 Couraud 1985, 139-143.
62 Couraud 1985, 148-149.
63 D'Errico 1995.
64 D'Errico 1995, 219, 286, 309.
68 D'Errico 1998, 25, 43.
70 D'Errico 1998, 47.
alternative sign systems. On a different level, since they are two-dimensional, the marks on objects of the second category, which may be utilitarian, also seem to convey a message following some code, and, in this respect, they should also be considered as signs in one or more sign systems.

Both categories have been studied till now by several authors and opinions on their interpretation diverge. Yet, it has often been argued that the sign systems of notation to which they belonged were related to counting, recording or to script in one of its most elementary and archaic forms.

II.2.a. Artefacts as signs

1) Evidence from the Near East

This is how ‘tokens’ (Fig. 1, right), small clay, and, more rarely, stone objects of the Neolithic Near East have been interpreted as traces of concrete counting. Schmandt-Besserat developed earlier theses by Oppenheim and Amiet. Based on the study of 8,162 tokens, she considered them not only as counting and recording devices, but also as the immediate precursor of cuneiform writing, by mutation of the three-dimensional tokens into two-dimensional graphic symbols (cf. Fig. 1).

The examples date from the 8th to the 4th millennium, have been found in a large geographical area, including Iraq, Iran, Syria, Turkey and Israel, and have various geometric shapes (cones, spheres, disks, cylinders etc.) and an average size of 1-3 cm. x 3-5 cm. According to Schmandt-Besserat, these tokens would have evolved to meet the needs of the economy, at first keeping track of the products of farming, then extending to goods manufactured in urban workshops. Such a system would permit easy manipulation and flexible storing of unlimited quantities of information, while being open, since new signs could always be added, but their volume was difficult to use and they could not dissociate numbers from the items counted. Tallies would be more efficient for permanent records, but their data could not be disassembled.

Several objections have been expressed vis-à-vis Schmandt-Besserat’s theory, mostly because she included ‘plain’ (geometric) and ‘complex’ (animals, vessels, tools) forms as part of the same reckoning system, which, moreover, would have been used during a very long period in different areas for the same function. Her six-stage model has not been proved stratigraphically. Moreover, ‘complex’ tokens may also be interpreted alternatively as amulets, pendants, game pieces, miniature vases or models. Though at least some of them are clearly indices and icons, they have not been proved to fit into a single semiotic system, nor is it clear to which particular system(s) they belonged, since various other semiotic systems must have existed, among others,

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73 The fact that an object possibly has a practical function does not preclude its having a symbolic value (cf. D’Errico 1995, 288).
74 Lately Schmandt-Besserat 1996, 11; see also bibliography in Zimansky 1993, 517.
77 Schmandt-Besserat 1996, 8.
79 Schmandt-Besserat 1996, 1.
80 Schmandt-Besserat 1996, 92-95.
81 Zimansky 1993; Glassner 2000, 87-112.
82 Matthews 1998, 15.
83 Ifrah 1994, 240.
84 Zimansky 1993, 515.
The varied modes of representation used in these ‘small clay objects’ would show diversity of functions. Three-dimensional examples might be imitations of objects, but two-dimensional (flat) ones would rather be representations of representations; relative disparity in size and the presence of perforations in some cases only would also indicate functional variety.

Furthermore, Schmandt-Besserat’s theory has been criticised because the tokens she identified as livestock or textiles are comparatively very few, while keeping track of livestock would be expected for the Neolithic period, and textiles are common in later cuneiform documents. Besides, plain tokens would not represent specific commodities constantly over the millennia over the entire Near East; similarities over this time span may be due to the fact that the basic geometric forms, which can be used in early numerical systems, are few.

In spite of the critics, in the absence of any other alternate explanation, several scholars agree now that a part, at least, of the later tokens were counters. The 4th millennium ones represented quantities, which would play an important role mostly in economic processes, according to Nissen. If each token represented a counted unit, a small heap of tokens would represent the sum of the counted units. At a very early date, a particular number of units of the same value could be replaced by a specific symbol. By combining various symbols, relatively high numerical values could be obtained. Even though the true meaning of their shapes is not clear, the large quantities of clay tokens found in various geometric shapes may have been the representations of different numerical values. With the differentiation of shapes and sizes, a second quality was added to their meaning. They were changed from indices to icons and/or symbols. By the mnemonic means of differentiated shapes, specific information was transmitted concerning the nature of the represented objects, such as the product type, the units they were measured or counted in, etc. If markings on tallies had unlimited possible interpretations, each clay token was now a distinct sign with a single significance; thus tokens also contained qualitative information.

According to Schmandt-Besserat, from the 6th millennium tokens were often located in storage facilities and warehouses, partly inside and partly outside domestic and public (since the 5th millennium) buildings, most often associated with early summer deposits (4th millennium). They would have been discarded after the harvest, as soon as their (recording?) function had been fulfilled. They were therefore used primarily for record keeping rather than for reckoning and they were not related to trade and, in particular, obsidian trade. In Uruk, they were discovered occasionally in fireplaces, either intentionally in order to be baked, or discarded. They may be found on the floor, sometimes clustered together, as if they were kept

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87 Zimansky 1993, 516.
88 Zimansky 1993, 516-517.
91 Nissen et al. 1993, 11.
92 Lieberman 1980, 343.
93 Nissen et al. 1993, 127.
94 Schmandt-Besserat 1996, 95.
95 Schmandt-Besserat 1996, 33, 40.
98 Schmandt-Besserat 1996, 31. They occur in non-domestic architecture in later periods and were sometimes found, with other status symbols, in burials of prestigious individuals, suggesting that they were used by members of the elite (Schmandt-Besserat 1996, 37).