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IMPRACTICAL PRECISION OF CALENDARS

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What are calendars for? The question has at least two strata: practical an symbolic. What are the relative merits of these two lines of reflection on the nature of these cultural artifacts? The positivist bias present in the historiography of astronomy of late 19th c. and early 20th c. meant that attention focused exclusively on utilitarian purposes. This paper proposes to examine one of the claims which used to be often repeated in this context, viz., that the original motivation for the development of calendars was agricultural scheduling. We will submit a quantitative analysis of the precision of calendars, and of the requirements of scheduling in agriculture, arguing that the latter do not readily explain the former, offering an argument for a less utilitarian purpose of calendars.

INTRODUCTION

This paper primarily follows up on one of the questions raised by my Exton[1] paper[2] which presented the symbolism underlying timekeeping as an often overlooked but key aspect of chronology across cultures. This position contrasts with "received knowledge" which focuses on the practical aspects of timekeeping.

Here is a typical example of the "received knowledge" which I found at a random bookseller, in a random children's book on astronomy:

> The earliest astronomers were actually farmers and shepherds. They studied the sky to predict the changing of the seasons. Ancient Egyptians could tell by the movement of the stars when the Nile River would flood each year. They were able to figure out the right time to harvest their crops before the floods began. [3, p. 4]

This statement is obviously inaccurate. An archaeologist could demonstrate by how many millennia the early origins of astronomical observation predate the "farmers and shepherds". An Egyptologist could quantify how (un)successful the Egyptians were in predicting the floods, and how (im)plausible is the claim that Egyptians used astronomy to predict floods. A historian could trace the history of this particular thought, explaining its philosophical antecedents, identifying its first occurrence and the context of the various debates in which it was employed.

This paper does not have the ambition to do justice to any of the above. I would merely like to indicate some elements of interest, pointing out a quantitative argument which astronomy can contribute to the analysis.

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NILE, SIRIUS, AND FLOODS

Already in the 1930s Otto Neugebauer[4,5] became intrigued by the claim that Egyptians somehow used astronomy to predict the annual floods. While it is true that they celebrated the heliacal rising *Sothis* (Sirius) as the herald of the beneficial inundations, it is unclear whether this astronomical connection was ever used in agrarian timing.

The origins of the best known Egyptian calendar, used to date records of momentous events, and therefore known as the "civil" calendar (as opposed to the "religious" lunar calendars governing certain feasts), are obscure. This "12 x 30 + 5" calendar is a particular enigma because of its astronomical nonconformity which must have been obvious very early on. It follows neither the sun nor the moon, and its merits lie in its regularity. Indeed, it is arguably the oldest perfectly regular, algebraic calendar, requiring no observations (and records thereof). For this very reason it was the calendar preferred by astronomers for centuries, up to and including Copernicus.

Neugebauer[4] suggested that it is precisely its astronomical nonconformity which led Egyptians to turn to the heliacal rising of *Sothis* as an index of the inundations. I shall not attempt to judge whether his theory is correct or not (for a critical appraisal cf. [6, 7, §256], etc.) but only retain two elements. Firstly, serious researchers have been trying for a long time to elucidate the connection, mentioned in ancient texts, of the inundations, the heliacal rising of *Sothis*, and the "12 x 30 + 5" calendar. It still remains unclear whether the correct reconstruction of the events has been found. And secondly, the floods are, and always have been, highly irregular. Already Neugebauer himself felt[5] that he had to examine the part of his argument where he claimed that 50 years of observations of the periodicity of the floods would have allowed to determine an average period of 365 days. In view of colonial-time observations[8] this claim was already questionable in 1904. In fact, later studies[9] have shown that the inundations were (and still are) so erratic that decades of records might not have yielded an average of 365 days. What is more, it has been pointed out that "a less than direct averaging method implies that the answer was known in advance — else why use a method to better approximate 365 days?"[9]

The claim that "ancient Egyptians could tell by the movement of the stars when the Nile River would flood each year; they were able to figure out the right time to harvest their crops before the floods began" [3, p. 4] therefore is overly simplified to a point of misrepresentation. Where does it come from? I have not traced its history to its roots but I propose several remarks that, in my opinion, shed light on the mentality which could have fostered such a manifestly inaccurate claim.

HISTORIOGRAPHY OF SCIENCE

The way historians of science approach their subject matter is changing. Generally speaking, the trend is "from anachronic internalism to diachronic externalism" [10, p. 333].

Considering methodology, a significant shift occurred after World War II. Historiography of science up to the 1940s was largely *anachronic*, aiming to understand the origin of today's knowledge, and asking how did this knowledge, which is assumed to be true and accurate, evolve from the primordial erroneous attempts. Such an approach was typical of authors with no formal training in the methodology of historical research.

More recent historiography of science is *diachronic* or *contextual*, studying the events in their historical context, considering the views on the purpose, meaning and methods of scientific research as they were understood at the time. This approach is the current standard among professional

historians in general.

Considering the underlying philosophy, another shift occurred, in the subsequent years. Towards the end of the 18th century, thinkers of the Enlightenment, and their Positivist successors in the 19th century, tended towards the view that science is not only a key factor in the development of humanity, but rather that it is the very essence of historical development in general:

> "Science is the absolute organ of culture, and the history of science is the history of humanity." [11, p. 596]

This view is known as *internalism*. Obviously, in this case, a historian of science does not need a profound understanding of the historical context. Thus, internalism goes very well with anachronic methodology.

The 1970s heralded the dominance of *externalism*, embracing an antipositivist philosophy of science, and focusing on the sociological and cultural setting and aspects of science which is typically reduced to the status of one artifact and institution among many.

WHAT MATTERS?

In order to illustrate the anachronic attitude, and also some of its intrinsic philosophical underpinnings, let us examine this text by an author of the first half of the 20th century:

> "What caused primitive man to raise his eyes from the earth toward the sky above him? Was it the beauty of the starry heavens, colour and pattern, that caught his eye? Did the stately regularity of their motion across the vault, with irregularities superimposed, provoke his curiosity as to the cause? In later times these may have been driving and inspiring forces, but primitive man had so hard a struggle simply to make his life secure that there was no room for luxury incentives." [12, p. 19]

Historians of religion explain that our culture is atypical, introducing a distinction between the sacred world of symbols, myths, and rituals on the one hand, and the profane world of everyday (pre)occupations.[13] We tend to regard the latter as the only one that truly matters, and the former as merely optional, as if practical concerns and the "bottom-line" were the only thinkable objectives of our activities. In this we are the exception. In fact, when considering historical events we tend to project our pragmatic mentality onto the past.

For countless millennia the meaning of all human activity was in its link with the timeless models of gods and heroes. A hunter could not take a life without appropriate ritual. A farmer tilling the earth and sowing the seed was performing a ritual, emulating the hierogamy of creation. A judge sentencing a criminal was ritually separating the community from the offender, ensuring that the wrath of the gods would not extend to the whole community.

What mattered was the symbol and the ritual. This does not mean that the pragmatic aspects were less important. It is not a question of importance but of significance. And in this context, if actions had no symbolic significance, they had no significance at all. If an action did not signify anything, it was not considered at all: it did not matter.

We tend to assume that the distinction between "luxury incentives" such as symbolism, and "practical incentives" such as survival, must be applicable universally because it appears as perfectly natural to us. This assumption contributes to our perplexity when trying to understand the motivations of the builders of Stonehenge, the Easter Island *moai*, the pyramids, etc. We do not understand why societies barely capable of sustaining themselves would have expended so much effort on projects of no "practical" value.

And yet, the answer is elementary. They simply did not have the same notion of "practicality" as we do. Those things that benefited the society the most were regarded as the most significant on the symbolic level, and vice versa, the most symbolically significant tended to be regarded as the most beneficial. Therefore those individuals who disregarded the sacred symbols were also feared as public enemies, jeopardizing the very physical survival of the whole society.

My quotation from the book for children[3] also implies that the first attempts at astronomical observations would have impressed ancient societies by their usefulness. Their usefulness may impress us but, most likely, this very category would not have been perceived as relevant at the time. Indeed, the starry sky is a spiritually stimulating spectacle, the inspirational power of which has left its mark upon all human cultures and civilizations. Systematically disregarding these aspects of early astronomy, internalist historiography arbitrarily excluded a major factor from its field of study. Attempts to reduce the motivation behind the origins of astronomy to "practical" purposes are an example of why serious scholars have abandoned the anachronic method.

Philosophical and methodological reservations aside, what sort of a scenario could one imagine to explain the first observations as guided by "practical" purposes? Only someone used to paying close attention to the starry sky would have noticed, after several years at the very least, the coincidence of the inundations and the heliacal rising of *Sothis*. Let us assume for a moment that "primitive man had so hard a struggle simply to make his life secure that there was no room for luxury incentives": only "practical" objectives are admissible. Any "practical" application of astronomical phenomena can only be discovered by individuals who have invested considerable time in developing their observational skills. If only practical objectives are admissible, how could such individuals have gained their skills? People mindful of the "practical" and only of the "practical" would have never been able to reach any "practical" and "useful" astronomical discoveries.

CALENDARS AND AGRICULTURE

The most primitive timekeeping device is the simple counting of days. It is unclear when exactly the regularity of the lunar cycle was discovered and linked to timekeeping. In the very early period (as attested even today by isolated populations), one indicated a date for a meeting by referring to the number of days or to the phase of the moon.

A lunar calendar is singularly "impractical" for the purposes of an agricultural society which naturally synchronizes its rhythm with the tropical year. Whether or not a fully-fledged calendar existed in pre-agricultural societies, the moon was such an established timekeeping device that the earliest calendars were lunar[14,15] regardless of "practical" considerations.

Lunar timekeeping was much more naturally linked with the life of a hunter-gatherer society. Even today, full moon is sometimes referred to as "hunter's moon". In classical antiquity, the goddess Artemis/Diana was a virgin (a reference to a regular monthly cycle, undisturbed by motherhood) huntress whose attribute was the moon (in many cultures associated with the feminine).

Although the Neolithic Revolution brought about many changes, the shift from lunar to solar,

or rather lunisolar, timekeeping did not take place (if at all) until much later. In fact, where it did happen (Egypt, Mesopotamia, China) it did so as late as the dawn of historic times. What is more, lunar timekeeping was never fully abandoned. The Egyptians used at least two separate calendars: the old lunar one(s) alongside the civil solar one. In many cases, astronomical conformity (most clearly seen in the case of the moon) was not adhered to. The Athenians and the Romans, in particular, took great liberties with it but never fully abandoned the notion. The most radical attempt to disregard the phases of the moon entirely was the Julian reform of the calendar, although it can be argued that at the time it was assumed that traditional lunar or lunisolar calendars would continue to be used to determine various celebrations and festivals. The Christian version of the Julian calendar and the Gregorian calendar both are ostensibly solar but contain covert lunisolar calendars (derived from the Babylonian one), governing the most important celebrations ("movable feasts").

It is well known that already Hesiod[16] mentions heliacal rising and other astronomical phenomena as the basis for agrarian timing. The significance of such testimonies is important. I claim that they are often misinterpreted, however, as if they made it clear that the ancient farmers in actual practice synchronized their work with the stars. While it is indubitably true that in agricultural societies in general there is a profound awareness of the symbolic link between the rhythm of the cosmos and the rhythm of farm work, it does not follow that astronomy was the only, nor indeed the main, timing method. It suffices to consider what farmers and gardeners do in real life (rather than in Hesiod's religious poems or on the pages of various learned histories of astronomy). They determine the opportune timing primarily by monitoring the weather and the development of the crops. Naturally, calendric (and astronomical) information is also taken into account but it is rarely the main factor.

As I have pointed out in my Exton paper,[2] "symbolism can suffer some astronomical inaccuracy" and "symbols work as long as they are perceived as grounded in reality: timekeeping symbols work as long as they conform to astronomical phenomena at least in some way that would allow the general perception to persist." In other words, Hesiod's treatment of the symbolic unity of microcosm and macrocosm can hardly be used to argue about everyday farming practices. On the other hand, it is quite plausible that in some societies the actual practice was more under the sway of heavens than in others but I consider it highly unlikely that a farming society would prefer to wait for a heliacal rising while overripe fruit was falling from the trees.

Apart from the day-to-day decisions about farm-work timing, farmers also need to plan. Planning on a farm is, generally speaking, from one season to the next. There is no need for accurate timekeeping on the level of centuries. Agrarian societies, however, develop annual festivals celebrating the solar (tropical) cycle, adding them to the repertory of the more ancient feasts celebrating the lunar cycle. It is on this ritual and symbolic level that regularity is much more significant. Indeed, repetition, which is a realization of timelessness, is a key feature of any ritual. As Plato says, "Time is the [cyclically] moving image of eternity" (*Timaeus,* 37c-38c).

ACCURACY OF CALENDARS

Considering what we would call "practical farmer's needs", could they fully justify the development of calendars? I would like to advance the argument that the sophistication of calendars exceeds such requirements. Consider the long-term mean conformity with astronomical cycles, which I shall refer to as the *accuracy of calendars*. The first calendars were empirical, i.e., based on day-to-day observations rather than on an arithmetic algorithms. The notion of calendar accuracy is, however, only applicable to calendars based on arithmetic algorithms.

Calendar	solar cycle	lunar cycle
Egyptian civil (2778 BC)	$7 \cdot 10^{-4} = 59$ s/d = 6 hrs/yr	N/A
Julian (AD 325)	$2 \cdot 10^{-5} = 1.8$ s/d = 11 min/yr	$2 \cdot 10^{-7} = 17$ ms/d = 6 s/yr
Hebrew (AD 358)	$1 \cdot 10^{-5} = 1$ s/d = 6 min/yr	
Gregorian (AD 1582)	$8 \cdot 10^{-7} = 73$ ms/d = 27 s/yr	

Table 1. Accuracy of algebraic calendar schemes (as opposed to observational or empirical calendars). The dates in parentheses indicate the time when the algorithm was consolidated. In the case of the Julian calendar, this has to do with the *calculus* of the date of Easter (based on an underlying lunisolar calendar).

I claim that it exceeds what we would consider "practical" needs of a farmer. To quote just one popular book[3] among many, "farmers... studied the sky... they were able to figure out the right time to harvest their crops". It is possible that some farmers "studied the sky" but I feel that this description does not present the whole picture.

Considering calendars, we know from anthropologists that agrarian societies with little social stratification do not have fully-fledged calendars. Such calendars were simply too complex, required written records, a multigenerational effort, and therefore an institutional continuity spanning generations. This is not a job for farmers, nor is it a job justifiable by the needs of farming. The first calendars, which were empirical, required designated, specialized observers. They were primarily used to determine the times of feasts. Some of the feasts themselves would have represented a ritual link between the cosmic and agrarian cycles: but it does not follow that farm work itself was scheduled according to astronomical phenomena. Very early on, therefore, calendars and the underlying astronomy, were the business of specialists: shamans and priests, rather than the farmers themselves.

In my Exton paper[2] I noted the "general trend to replace empirical timekeeping with calculated schemes which do not follow the actual astronomical phenomena but mean parameters," presenting the example of the Jewish calendar:

> "This tendency has been evident throughout the history of timekeeping. Let me recall the example of Jewish timekeeping which, until AD 70, was strictly empirical. The months were meticulously observed according to the phases of the Moon and solar years were kept according to the Metonic cycle. After the Jewish-Roman wars, however, Hillel II, president of the Sanhedrin (AD c. 320-385), enacted a transition to a calculated calendar scheme. I find this particularly revealing because of the contrast with Judaism's insistance on accurate observance of the ritual rules and regulations: even the Great Sanhedrin capitulated under expediency's inexorable pressure, abandoning the strict, empirical coupling of Jewish feasts and festivals with the Heavens."

Arguably the first calculated calendar was the Egyptian "12 x 30 + 5" scheme, introduced probably in 2781–2778 B.C.[17,7] In broad terms, this was a solar (rather than lunar or lunisolar) calendar. The discovery of the Metonic cycle by the Chinese (14th c. B.C.?) and the Babylonians (7th c. B.C.?) led to the introduction of several calculated lunisolar schemes.

Accuracy of calculated calendars is a long-term property. On a timescale of several decades, even a relatively inaccurate calendar, such as the Egyptian one, is quite adequate for the "practical purposes" of farming. Table 1 provides an overview of some of the calendars. As I claimed in my Exton paper,[2] the main reasons motivating a society to introduce and refine a calendar so that it would conform to astronomical cycles, are hardly reducible to what we would perceive as "practical".

CONCLUSION

I agree that practical purposes have contributed to the origins and development of timekeeping. I maintain, however, that symbolism has been the dominant force underlying the history of timekeeping. The very accuracy of calendars suggests that agriculture did not dominate their development.

Timekeepers of the past did not judge their creations by what *we* would view as "practical considerations" but rather they saw their significance in what they signified: a link between the human world and the timeless world of gods and heroes, ensuring life and prosperity of the society by emulating these models. As L. E. Doggett succinctly puts it:

> "Calendars serve as a link between mankind and the cosmos."[18,19]

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