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1998 PRESIDENTIAL ADDRESS
'Why don’t you get in step?’ said my Polish-born Israeli friend. ‘The metric system is decimal all the way—decimal is the natural way to count (my emphasis, WJS), so metric is the natural way to measure.’¹

The metric system was designed to be a pure decimal system with convenient weight-volume-liquid measure equivalents. That is, one gram of water is one cubic centimeter of water is one milliliter of water, and one calorie of energy will raise one gram (or cc or ml) of water one degree Centigrade (now Celsius). The apparent advantages of the metric system are even more obvious when we consider the disadvantages of the foot-pound-second system. The foot is divided by twelve rather than by ten, and as the system was built up by accretion, convenient correspondences between weight and volume are rare. For example, there are 0.0362 ounces of water per cubic inch or 62.5 pounds per cubic foot. What kind of correspondence is that? So my friend’s claim is all the more pointed, in view of the demise of the metric standardization board in this country. If metric is so natural, why is it still struggling against traditional systems of counting and measuring in more than one part of the world? I refer here not to official government standards, but to systems in daily use among the people. If the metric system were so natural, it would only be necessary to introduce it to the people and it would immediately supplant any other system.

Still, the metric system is not without warts. First, the size of the standard weight measure seems arbitrary, no matter what system we consider. Second, the standard length measure seems arbitrary, too. That is, the kilogram and meter are themselves no more natural or useful than the pound and foot. Or the stone and ell, for that matter. Most important, the number ten is not all that convenient, arithmetically. It can be divided evenly by two and five, but not by three or four. Twenty would be a better number as the base of a counting system, as it is evenly divisible by four in addition to two and five. Twelve would be better yet, as it is evenly divisible by two, three, four, and six. Sixty, with divisors of two, three, four, five, six, ten, twelve, fifteen, twenty, and thirty, would also be advantageous, even though sixty seems a bit too large to use as the base of a counting system. Moreover, several numbers, including some of these, actually have been used as the bases of counting systems.
That is, in the English-speaking world alone, there have been several competing systems of counting and measuring in use over the centuries.

All of this leads to several questions:
1. What counting systems have been used?
2. Why have these systems been used?
3. Why have other systems not been used?

Presumably, the answers to these questions should tell us exactly what is ‘natural’ to the human race in terms of counting systems. The first step in seeking answers to these counting questions is the determination of the characteristics of a system. To do this, I examine the Arabic numeral system we use.² Having determined the characteristics of a counting system in arithmetic terms, we can look for evidence for various counting systems in the language. This requires the linguistic analysis of the names for numbers used in English. In this way I demonstrate three things:
1. five counting systems have coexisted in English;
2. all five systems are relatable to the human body; and
3. possible systems which are not used in English are not relatable to the human body.

In sum, a ‘natural’ counting system is one which can be derived from the original computing machine—the human body—and decimal isn’t the only way to go.

Before proceeding, there are two points of confusion I wish to clear up, or rather avoid. First, in a linguistic study of numbers, a number reference, whether written in digital or alphabetic form, refers to two distinct concepts, one arithmetic (the quantity or the position on the number line), the other linguistic (the word). Therefore, in the rest of the study, I will use 10 for the quantity and ten for the linguistic element. Second, both of these concepts can be called numbers. To distinguish between them referentially, I call the quantity 10 a numeral and the word ten a number name.

1. Arabic Numerals. To determine the characteristics of a number system, consider the system of Arabic numerals, which is organized to the base 10. Its salient characteristics are easily listed.
1. There are ten distinct simple numerals: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. Call this the uniqueness characteristic of the system.
2. Each multiple of the base starts a new sequence of simple numerals: 10, 20, 30, etc. Call this the multiple cyclicity characteristic.
3. Each additive of the base hits the same place in each sequence: 21 + 10 = 31, 31 + 10 = 41, etc. Call this the additive cyclicity characteristic.
4. When all the numerals in the sequence have been run through, a new sequence begins: 0, 10, 100, 1000, etc. Each of these represents a power of the base. Call this the exponential cyclicity characteristic.

These are the four arithmetic characteristics of a counting system. There must be linguistic evidence of this sort in the morphology of number names if we are to
identify a counting system in the Englishlanguage. Therefore I turn now to the set of number names in English to show what characteristics appear to have parallels in number name morphology. Each grouping of characteristics proves the existence of a counting system. With each identifiable system, I first detail the linguistic evidence for the system, then give the human-body source for the system, and finally give examples of the applications of the system to show that it actually has had wider influence on the lexicon of English.

2. The Decimal System. There are three major counting systems for which there is substantial evidence in the system of number names in English. The decimal system is the one with the largest amount of linguistic evidence corresponding to the arithmetic characteristics listed above; in fact, there is linguistic evidence for all of the arithmetic characteristics involved. I present this linguistic evidence in the order that the arithmetic characteristics are outlined above.

Consider first the uniqueness characteristic, the set of number names. A decimal system must have ten distinct number names, and English does: one, two, three, four, five, six, seven, eight, nine, and ten. Moreover, like the Arabic numerals, these names are morphemically simple. Both the set of Arabic numerals and the set of number names under consideration are to the base 10. Note that the unique set of number names is not derived from the unique set of Arabic numerals. Nine members of each set refer to the same quantity. But 0 ‘zero’ is the tenth member of the numeral set and ten is the tenth member of the number name set. Even so, the basic set of number names in English fulfills the uniqueness requirement for a decimal system.

The second characteristic is multiplicative cyclicity. Each multiple of the base 10 is a 2-place numeral with the second numeral a 0 and the first numeral telling which multiple of ten it is. If we look at the number names for multiples of ten, we see a parallel pattern: twenty, thirty, forty, etc. all have two morphemes. The second is always -ty, which is a form of the number name ten. The first tells which multiple of ten it is. That is, twen- is a form of two (cf. twin), thir- is a form of three (cf. third), and so on. The multiplicative cyclicity requirement is thus fulfilled.

The third characteristic is additive cyclicity. That is, adding the base to any number produces a sum which occupies the same relative place on the next higher sequence. In other words, since 10 + 23 = 33, adding ten to twenty-three should give a number with the name thirty-three, and it does. Thus the additive cyclicity requirement is also fulfilled.

The last characteristic is exponential cyclicity. That is, a counting system contains a cycle of cycles: when the base number is multiplied by itself, what results is a new cycle. In numerals, this means adding a place; in language it means a unique number name. Indeed, the name for 100 is hundred and the word for 1000 is thousand, words which are unique and are not linguistically related to ten in any way.
All of the arithmetic characteristics for a decimal counting system are fulfilled in the set of number names in common use in the English language. This might seem like a self-evident conclusion, but there is no guarantee that the use of a decimal system in arithmetic writing (Arabic numerals) signals the use of a decimal system of counting in the language. The Arabic numerals are restricted to the representations of the mathematical system. They were introduced long after the number names in English had come into use. I show below that the use of Arabic numerals has not eliminated the other counting systems.

Now consider the source of the decimal system. The numeral $10$, as remarked above, is not a particularly convenient number on which to base a counting system: it is evenly divisible by only the numerals 2 and 5. Of course, the numeral 5 has some mystical significance, as in its appearance in the pentagram. But the most compelling argument for the use of 10 as the base of a counting system is in our possession of 10 fingers, 5 on each of 2 hands. Further justification is unnecessary.

The applications of the decimal counting system are too many to be listed in full here. Our coinage, the metric system, and the readiness with which our ancestors adopted the decimal-based Arabic numerals are all evidence for the utility of the decimal system.³

But the decimal system does not stop here. There is also evidence for 2 other counting systems related to the decimal system. The first of these is the ‘didecimal’ system with a base of twenty. There is a special name for twenty, that is a score (the uniqueness characteristic). There is also evidence for twenty as a turning point in the decimal system in English. Specifically, the linguistic element meaning ten changes form at twenty. That is, ty is missing the n of ten/teen.

The source for a didecimal system can easily be seen in our possession of 20 digits: 10 fingers and 10 toes. Counting by score has largely gone out of practice today. Indeed the practice would undoubtedly have died long since had it not been for its famous invocation in the opening phrase of Lincoln’s Gettysburg Address (‘Four score and seven years ago…’). In fact, the only commonly-used relic of the didecimal system is the unit of weight measure known as a ton, which is equal to a score of hundredweights. There are other didecimal terms for types of money (double sawbuck, double eagle), but they are no longer in common use.

The didecimal system has fewer applications and less linguistic evidence for its existence than the decimal system. But this is only reasonable. After all, for many months of the year, our northern European ancestors would have had their feet wrapped against the cold. Thus their toes would not have been available for counting.

The other counting system subordinate to the decimal system is the semidecimal system to the base five. There is a native English name for a group of five, a handful, which points directly at the human body source of this (sub)system. Very few applications of the semidecimal system survive. The only ones in common use besides handful are fifth, which originally referred to a fifth of a gallon, and nickel.
In short, the decimal system and its two subsystems, all of which derive from different ways of looking at our digit count, constitute one natural means of counting. But there are others. I now turn to one of these, the duodecimal system.

3. The Duodecimal System. There is less evidence in the English lexicon for a duodecimal system than for a decimal system, but there is a substantial amount. The uniqueness characteristic is fulfilled by the simple names for the first 12 numerals, specifically one through ten, as listed above, and eleven and twelve besides. The fact that eleven and twelve were not originally morphemically simplex is irrelevant here: one needs specialized etymological information to demonstrate the complexity. To the normal native speaker they are simplex. Moreover, it is only after twelve that the teens begin, and there is a special name for a unit of twelve: a dozen. There is also a special name for 12\times12 or 12^2: a gross. Exponential cyclicity is thus fulfilled. There is no evidence for additive cyclicity (characteristic 3), but there is evidence for multiplicative cyclicity. The number names dozen and gross act just like numerals in multiples. That is, we say ‘2 dozen’ or ‘3 gross’, with singular dozen and gross, just as we say ‘2 hundred’. This differs from normal, nonnumeral words like book, which always occur in the plural here: ‘2 books’. Thus two of the four arithmetic requirements are fulfilled completely and a third is partly fulfilled. This is sufficient evidence for us to posit the existence of a duodecimal system.

For a long time, the human body origin of the duodecimal system was a mystery to me. I had thought that this system was an exception to the general rule in that it had no relation to the human body and was based solely on the mystic nature of the numeral 6. In fact, the duodecimal system goes back at least to Babylon and probably to Sumer, and it might be interesting to review some of that history now.

Consider first the mystic nature of 6. The numeral 6 is evenly divisible by the numerals 1, 2, 3, and 6. The sum of these numerals is 12 or 2\times6. This makes both 6 and 12 very special numerals with deep mystical significance. In addition, notice that the number of days in a year is at most 6 days more than 360, which is 6\times6\times10. That is, the number of days in a year is the mystic number 6 multiplied by itself and by the number of fingers, itself twice the mystic number 5. Clearly, this was not to be explained as a mere coincidence. Instead, the gods must have intended that the year should have 360 days, with the extra days set aside as a festival. This is also why a circle is divided into 360°. The significance of 6 was also clear to the ancient Hebrews. There were 6 days of Creation followed by 1 day of rest. This constituted the basis for the week. Although the week superficially seems to be based on 7, it is actually based on the 6+1. Furthermore, the 6+1 corresponds to the division of non-astral bodies in the sky: 5 visible planets (Mercury, Venus, Mars, Jupiter, and Saturn) plus the moon in the night sky and the solitary sun in the day sky. The arithmetic identity 6+1=7 cannot override this combination of belief and observed fact to make six plus one psychologically identical to seven; the distinction is an important one. Furthermore, 12 tribes of Israel and the Number of the Beast...

Still, the human body source of 12 was a mystery until I saw a woman from the Pakistan-Afghanistan border country counting on her fingers. With her right hand only and using her thumb as a counter, she tapped each of her finger sections in sequence, starting with the outermost section of her little finger and ending with the innermost section of her index finger. Thus the human body source of the duodecimal system derives from the ability of the opposable thumb to touch 12 finger sections.

There are many applications of the duodecimal system: 12 inches in a foot; 12 sidereal months in the year; 60 or 12 × 5 (a dozen times a handful) minutes in an hour or seconds in a minute; 24 or 12 × 2 hours in a day; 6-sided dice; and 12 ounces per pound in troy weight. There are also fractional uses: 1 fathom is 6 feet or half of 12 feet; 1 yard is 3 feet, which is one-fourth of 12 or one-half a fathom.

Moreover, the duodecimal system has retained its hold over the decimal in one area, even in those lands where metric otherwise holds supreme, like France: the measurement of time. As noted above, the number of seconds in a minute, of minutes in an hour, and hours in a day are basically duodecimal. Why not a metric clock? 100 seconds in a minute, 100 minutes in an hour, and 10 hours in a day. This would give 100,000 seconds in a day. Under our duodecimal clocks, we have 60 × 60 × 24 = 86,400 seconds in a day. A decimal second would be .864 of a duodecimal second, which is not a major discrepancy. In fact, decimal clocks were constructed in France during the 18th century, and I am told some of them, still working, can be found in museums there. Moreover, the decimal second would be closer in size to a human heartbeat than the duodecimal second is. But decimal timekeeping was never even a minor threat to the duodecimal.

Thus, both by the lexical evidence and by its applications, the duodecimal system is every bit as natural a system of counting as the decimal system. Nor is it the only alternative to the decimal system. Another strong alternative is found in the binary system, to which I now turn.

4. The Binary System. The simplest possible counting system is a binary system. It has only two numerals (0,1), but you can do anything with it arithmetically that can be done with a decimal system. The English language abounds with evidence for an ancient and well-used binary counting system. Let us consider that evidence now.

First, there are obviously unique and simple names for 1 and 2. These names are also found in the decimal and duodecimal sets, but this does not matter. What matters is that they satisfy the uniqueness requirement.

Second, the English language has many special names for groups which are the size of the base, e.g., twin, pair, couplet, duo, and couple, to name a few. Some of these are native words, others have been borrowed. Some are very general in meaning, others very specific. For example, a couple indicates 2 of anything; a couplet is 2
closely related lines of verse in poetry. But these distinctions cause no difficulties, as
the base numeral has a unique name. This is also part of the exponential cyclicity
characteristic, to which I return below.

The requirements for additive and multiplicative cyclicity are not met in the
binary system. The reason for this is that they are superseded by other factors.
Remember that additive cyclicity applies between 10 and 10^2. There is only one
number between 2 and 2^2, so there is only this one opportunity to get evidence for
additive cyclicity in the binary system. If the evidence is lacking here, it will be
found nowhere else. But the lack of evidence for additive cyclicity here is not cripp-
ling, and in fact it fits with certain other indications. Recall that there is no word
like *oneteen for 11. This is because 11 has the name eleven, which is part of the basic
set for the duodecimal system. Extrapolating from this example predicts that evi-
dence for additive cyclicity in the binary system will be lacking. That is, binary 11 is
already 3 in all the other counting systems, where it has the number name three.
This name supersedes any binary equivalent name, just as duodecimal eleven sup-
ersedes decimal *oneteen.

The lack of evidence for multiplicative cyclicity is less troublesome. Note that
multiplicative cyclicity overlaps with the exponential cyclicity in the binary system.
That is, 2 x 2 = 2^2. What happens in such a case is that exponential cyclicity super-
sedes multiplicative cyclicity. Thus we have names for 4 or 2^2 (= binary 100), e.g.,
foursome or quartet, and for 8 or 2^3 (= binary 1000), e.g., octet. This parallels what
happens in the decimal system: we say hundred and not *tenty, and although itis
possible to say ten hundred, thousand is now the normal number name. Thus, in
the decimal system, wherever the exponential cyclicity and the multiplicative cyclic-
ity overlap, the former takes precedence. In the binary system, exponential cyclicity
and multiplicative cyclicity overlap everywhere between 2 (= binary 10) and 4
(= binary 100). The exponential cyclicity should take precedence, so there should be
no evidence for multiplicative cyclicity in the binary system. And there is not. But
there is minimal evidence for four as a breaking point. The allomorph of ordinality
becomes -th for the first time at fourth. It is just not clear whether this is evidence
supporting multiplicative or exponential cyclicity.

In sum, given the particular arithmetic qualities of the binary counting system,
there is as much linguistic evidence for a binary system in the English lexicon as
possible. It could even be argued that the evidence for the binary counting system
exceeds the evidence for the duodecimal system, because it fulfills a higher per-
centage of the possible requirements.

The human body source for the binary system is again obvious. Not only hu-
mans but all higher orders of the animal kingdom display bilateral symmetry. More
to the point, our counting organs come in pairs.

The applications of the binary system are extensive in the area of weights and
measures. For example, 2 gills make a cup, 2 cups make a pint, 2 pints make a quart,
2 quarts make a magnum, and 2 magnums or 4 quarts make a gallon. These
correspondences may seem annoying from a decimal point of view, but they are perfectly reasonable and simple in the binary system.

Now consider the distance measure. 2 steps make a pace. Traditionally, the military standard required (and requires) a single step of 30 inches or 2.5 feet. A pace is thus 60 inches or 5 feet. Our word mile is from the Latin expression *mille passuum* ‘thousand paces’ or 1000 x ((step length) x 2). The mile was originally 5000 feet, a combination of semidecimal, decimal, duodecimal, and binary systems.

Shifting to music we find everything based on binary. The basic unit of pitch is an octave consisting of 8 ($2^3 = \text{binary} 1000$) notes. The basic unit of timing is given in binary divisions of the whole note: half notes, quarter notes, eighth notes, and so on.

The unit of weight, the pound, is divided into 16 ($2^4 = \text{binary} 10,000$) ounces, and thus properly belongs to the binary system as well. It is here that we also see the emergence of liquid measure-weight-volume correspondences. As the old saying has it, ‘A pint’s a pound the world around.’ Thus a cup is 8 ounces and a gill is 4 ounces; a quart is 2 pounds or 32 ounces and a gallon is 8 pounds or 128 ounces. At the same time a cubic foot of water weighs 62.5 pounds. This means that 8 cubic feet of water (a cube of water 2 feet on an edge) holds 500 pints or 500 pounds (= 1/4 ton) of water. There is no evidence to my knowledge that these correspondences were deliberately established; surely they were not. But the correspondences are too regular to be merely random, and I would argue that they evolved naturally and exist because they fit so well into so many systematic niches in the foot-pound-second system.

It is clear, then, that the binary system of counting has a long history with many applications and has interacted extensively with both the decimal and duodecimal systems. In fact, I submit that the binary system may be even older than the duodecimal. But the accuracy of my suspicion here does not affect the main line of reasoning: the binary counting system is old and well-used. Nor is it merely a fossilized remnant of some prehistoric era. We all know that computers operate in the binary mode.

These are the 3 systems of counting and measuring for which there is evidence in the lexicon of English. Before concluding that all counting systems are based on some human-body correspondence, I must pause for a short aside on the nature of proofs.

5. On the Nature of Proofs. In logic you may be able to begin a proof with a previously proved theorem or a simple hypothesis and proceed step by step to a conclusion. In the case of a simple hypothesis, showing that you can reach a given conclusion from the hypothesis is sufficient. Empirical verification can be developed by showing that the hypothesis is indeed true and by testing for the occurrence of new data as predicted by the conclusion.
The present case, however, differs from this. The hypothesis is not simple: ‘all English counting systems are relatable to the human body’ is universally-quantified. It requires proof that all the counting systems that occur are relatable to the human body and that no systems can occur which are not relatable to the human body. The former is the positive proof; the latter is the negative proof. Sections 2, 3, and 4 show the counting systems that occur in English and the fact that they derive from the human body. Since no other counting systems can be found for English, I consider the positive proof complete. It is now necessary to complete the negative proof.

6. The Negative Proof. Nero Wolfe was fond of saying that it is impossible to prove a negative. In fact, it is possible to prove a negative statement, so long as it has a relatively small set of circumstances to be tested. What faces us here, though, is a universally-quantified negative. That is, I have to show that each and every number which is not related to the human body cannot become the base of a counting system. This is the type of negative statement that Nero Wolfe was referring to. It is indeed impossible to prove.

However, it can be shown in detail that the weight of evidence supports this negative statement while there is no evidence against it. But in the interest of brevity, I will make a simplifying assumption and concentrate only on the numeral 7 and its multiples 14, 21, and 28. Except for the bases discussed above, 7, 14, 21, and 28 are the only numerals between 1 and 30 which show signs of having been used for enumeration purposes.

Consider 28 first. It is like 6, in that the sum of its factors is double itself. That is, $1 \times 28 = 2 \times 14 = 4 \times 7$, and $1 + 28 + 2 + 14 + 4 + 7 = 56$. Moreover, 28 is the minimum time for a lunar month and the number of days in the normal human oestrus cycle. But it is not used as the base for any counting system, in spite of the fact that $13 \times 28 = 364$, a better approximation to the length of the year than 360. Still, in spite of its advantages and mystic significance, 28 has not made it as the base of a counting system.

Consider instead 7. It is one of the factors of 28, and if it were the base of the counting system, 28 would automatically be included in that system, and its mystic significance would be captured. Beside its status as a factor of 28, 7 has entered into our culture as a lucky number. There are 7 sacraments, 7 cardinal virtues, 7 deadly sins, and 7 days in a week. 4 7-day weeks is the minimum time necessary for a lunar month and 52 7-day weeks is 364 days. But apart from the week, which can be interpreted as a (6 + 1)-day week, there is nothing that is reckoned by 7’s. There used to be a special numerical name for a week, a sennight, but it has fallen out of use. The same goes for fortnight, the name for a 2-week period. Note, however, that this argument is vitiated by the fact that the name is derived from a decimal number name (14 nights). With 21, there is even less to say: it occurs only as the winning point in certain games. But here it is the goal rather than the base, and this use can be
ignored. Thus, in spite of their mystic nature and potential usefulness, the evidence indicates that these three numbers are just not taken advantage of.

In fact, the situation is worse than this. There is at least one unit of measure that should be counted in groups of 7 and is not. I refer here to the musical scale. What we call an octave is in fact a septave. That is, 7 whole tones separate any 2 musical notes an ‘octave’ apart. The intervals from mi to fa in a major key and from ti to do are only half tones. All other notes in the scale are separated by whole tones. This total of 5 whole tones plus 2 half tones makes only 6 whole-tone intervals separating the 7 full tones in an ‘octave’. Moreover, some music has been composed for the septave or whole-tone scale, as it is called by musicians. Yet this music remains largely unknown and is only rarely performed. In short, the numbers 7, 14, 21, and 28 have two things in common: there is nothing on the human body that numbers 7, 14, 21, or 28, and there is no counting system based on any of them.

The same can be said for all the remaining numerals between 1 and 30, both those with mystical significance, like 9 or 13, and those without mystical significance, like 23. For this set of number names, then, the case is complete.

As another simplifying assumption in the discussion, I appeal to the millenium and a half history of the English language and assume that anything which has not turned up as the base of a counting system in that time will not turn up as such a base in the future. ‘It could still happen’ might be a reasonable act of faith, but this is a scientific essay.

Now the lack of evidence for any systems without human body correspondence is universal over the set of numerals defined. I believe it is universal over all numerals and cultures. But if anyone can show me evidence to the contrary, I will happily abandon my hypothesis.

There is one more body of data to be tapped to its full: units of measure. The organized attempt to find counter evidence by examining numbers individually failed. But there may still be evidence around. If there is, it should be in the units of measure. I turn now to an examination of these data.

7. Units of Measure. A quick survey of the traditional units of measurement shows a terrible mish-mash, except, presumably, for the metric system. The meter is currently defined as 1,650,763.73 wavelengths in a vacuum of the orange-red radiation of Krypton 86. This is surely arbitrary, unique, and stated with sufficient precision to satisfy any requirements of scientific objectivity. It seems highly unlikely that any other unit of measurement would correspond to the meter accidentally.

Conversely, consider the inch, the span (= 8 inches), the foot, the cubit (= 14 to 21 inches), the yard (= 3 feet or 36 inches), and the ell (= 45 to 54 inches). The name ‘foot’ suggests its origin: it is roughly the length of the owner’s foot, which is a convenient unit of measure for anything on the ground. Somewhat less obvious is the source of the span and the cubit: the former is a contraction of hand-span, the distance from thumb-tip to the tip of the outstretched little finger, and the latter is
from *cubitus*, the Latin for ‘elbow’ and represents the distance from the elbow to the wrist or the knuckles (which set?) or the fingertips. The yard is the distance from fingertip to nose, and the ell is the distance from the fingertips of 1 hand to the elbow of the other arm. Finally, the inch is the length of the first joint of the index finger. Given these sources for the traditional units of measure, it is easy to understand the wide degree of variation in them and their strange sizes, sizes which do not really correspond to each other. There is no real interconvertability. The inch equivalents of the larger units of measure were developed later but were originally approximate; even today, they do little to help.

Amid this chaos, the stability of the meter is refreshing, even if the length of the Kr86 red-orange line and the ratio $1,650,763.73::1$ mean exactly nothing ($= 0$) to the average speaker of English. Of course, we must remember that the meter has a checkered history. The meter was originally intended to be $1/10,000,000$ ($10^{-7}$) of the distance from the North Pole to the Equator. But when the accepted value of this distance was discovered to be in error, the standard length for the meter was changed to the distance between 2 scratches on an iridium bar kept at constant temperature and pressure in a cave in France. In 1960, when it was possible to control the length of the meter more precisely, the current equivalent was adopted. The meter is apparently unique among all units of measure in not originating with a human body part.

However, if the height of a human being is about 2 yards or 1 fathom, the height of human living space is roughly two meters. I am told by architect friends that it has been so for some time, since long before the invention of the metric system in the late eighteenth century. This suggests that the meter—or something of the same size but with a different name—has been around for a long time. Indeed, the meter is approximately the distance from the fingertips of one hand to the opposite shoulder. This is precisely the length of the longbow arrow known as a clothyard shaft. Thus the clothyard was renamed the meter, standardized in length, and chosen as the basis of the metric system.

In short, every standard unit of length used in the English language is derivable from a human body measurement. By itself, this is not only unremarkable but purely reasonable, from the viewpoint of a pre-technological society. Moreover, the correspondences, where they existed in anything like a stable fashion, are similarly interesting and reasonable: the relationship of inch to span is binary in nature, of inch to foot is duodecimal, of inch to yard is duodecimal, of cubit to yard is binary, of foot to yard is duodecimal, etc. These facts should be borne in mind as we turn to a summary discussion of the significance of the types of counting systems.

8. Discussion. I have demonstrated the occurrence of 5 distinct counting systems in English, grouped as 3 major systems (decimal, duodecimal, and binary) with two others (semi- and didecimal) classified as subsystems of the decimal system. All but the binary system are based on a number which has mystical significance, and all
Without exception have a human-body correspondence. Conversely, other mystic numbers which have no human body correspondence do not occur as the base of a counting system.

By themselves, these facts prove only that the correspondence between the human body and viable counting systems is possible, even likely. They do not prove that a system unrelated to the human body could not develop spontaneously. But it would be unreasonable and non-scientific to cling to the hope that such a development will occur. The evidence from the systems that do occur, from the measure systems, from the supposedly independent metric system, and from the musical system, which actually was developed independently of the others, all points to the same conclusion: the counting systems in use have human-body correspondences. Thus English morphology mirrors human morphology. Even if the total evidence is not absolutely conclusive, it is certainly overwhelming, and I find it persuasive. Moreover, the conclusions explain something which has long been a mystery to Americans: the traditional British monetary system, which can now be clarified.

The main units of the traditional British monetary system include the farthing, ha’penny, penny, tuppence, thruppence, sixpence, shilling, half crown, crown, and pound. At first glance, they seem to represent an incomprehensible collection of coins of arbitrary value. However, the relationships between coins are far from

<table>
<thead>
<tr>
<th>SMALLER COIN</th>
<th>LARGER COIN</th>
<th>MULTIPLIER</th>
<th>SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>farthing</td>
<td>ha’penny</td>
<td>2</td>
<td>binary</td>
</tr>
<tr>
<td>farthing</td>
<td>penny</td>
<td>4</td>
<td>binary</td>
</tr>
<tr>
<td>farthing</td>
<td>thruppence</td>
<td>12</td>
<td>duodecimal</td>
</tr>
<tr>
<td>ha’penny</td>
<td>penny</td>
<td>2</td>
<td>binary</td>
</tr>
<tr>
<td>ha’penny</td>
<td>thruppence</td>
<td>6</td>
<td>duodecimal</td>
</tr>
<tr>
<td>penny</td>
<td>tuppence</td>
<td>2</td>
<td>binary</td>
</tr>
<tr>
<td>penny</td>
<td>thruppence</td>
<td>3</td>
<td>duodecimal</td>
</tr>
<tr>
<td>penny</td>
<td>sixpence</td>
<td>6</td>
<td>duodecimal</td>
</tr>
<tr>
<td>penny</td>
<td>shilling</td>
<td>12</td>
<td>duodecimal</td>
</tr>
<tr>
<td>tuppence</td>
<td>shilling</td>
<td>6</td>
<td>duodecimal</td>
</tr>
<tr>
<td>thruppence</td>
<td>sixpence</td>
<td>2</td>
<td>binary</td>
</tr>
<tr>
<td>thruppence</td>
<td>shilling</td>
<td>4</td>
<td>binary</td>
</tr>
<tr>
<td>penny</td>
<td>half crown</td>
<td>30</td>
<td>decimal and duodecimal</td>
</tr>
<tr>
<td>tuppence</td>
<td>half crown</td>
<td>15</td>
<td>(semi)decimal</td>
</tr>
<tr>
<td>thruppence</td>
<td>half crown</td>
<td>10</td>
<td>decimal</td>
</tr>
<tr>
<td>shilling</td>
<td>crown</td>
<td>5</td>
<td>(semi)decimal</td>
</tr>
<tr>
<td>shilling</td>
<td>pound</td>
<td>20</td>
<td>(di)decimal</td>
</tr>
<tr>
<td>crown</td>
<td>pound</td>
<td>4</td>
<td>binary</td>
</tr>
</tbody>
</table>

Table 1. The Pound Sterling.
arbitrary. As can be seen in table 1, every inter-coin relation can be understood in terms of the three counting systems detailed above.

The traditional British monetary system is, in short, a combination of the binary, decimal, and duodecimal systems. In fact, there are 240p to 1 pound, and:

\[240 = 2 \times 10 \times 12. \text{Q.E.D}\]

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1 The ultimate inspiration for this study came from this comment, which was said to me when I was a student in Poland during a previous life. When I began working on the project, I recalled a pre-school boy who wondered why, if 11, 12 in Polish is *jedenascie, dwanascie*, English doesn’t have *oneteen, twoteen* (or even *onety-one, onety-two*). I completed a draft many years ago and put it aside. Jim Copeland's study (1998) on the derivatives of 'hand' in Tarahumara moved me resurrect it. For a more detailed analysis of contemporary English number names and a stratificational description, see Sampson 1970.

2 The system of Roman numerals would do as well, but the Arabic system is more familiar.

3 I realize that the Norse also had a decimal system of number writing.

4 Toby Griffen points out that the actual designation for a system to the base 20 should be *vigesimal*. He is, of course, correct; however, I am using didecimal because the system I describe here is, like the semidecimal system, subordinate to the decimal system. Some suspect that the didecimal system is of Celtic origin rather than Anglo-Saxon. Tim Pulyu assures me that there is insufficient evidence for this. But even if it is Celtic in origin, this is irrelevant for our purpose; it was certainly adopted by the English language. Moreover, languages like French and Russian have evidence for a didecimal system too. Though the French might also have adopted the didecimal system from the Celtic Gauls, such a claim would carry very little weight with the Slavs.

5 *Dozen* is of French origin, but this is irrelevant here.

6 I realize, of course, that a standard gallon of water is 8.35 pounds, which is not a particularly close correspondence. Remember, however, that the standardization of weights in the pre-modern era was anything but precise: they simply did the best they could with what they had. At the same time, a liter of water is exactly a kilogram only at 20.5°C and 1 atm. So even at the best of times, with the best technology and the best of intentions, metric correspondences are still only approximate.

7 Sampson (1979:78–79) points out other utilitarian features of the duodecimal system.

8 Except, of course, for the normal number of teeth in an adult, which is 28. But the total number may be as many as 32, and the actual number varies from zero in an infant to the maximum of 32 (and possibly back to zero again, because it is too easy to lose teeth to trauma, decay, or gum disease). Finally, even if a person has exactly 28 teeth, all of them are never visible at the same time. In practice, it is not easy to tell
exactly how many teeth an individual has. The combination of invisibility with variability makes this datum too uncertain to act as an actual human body foundation for base 28.

REFERENCES

