NUMBERS AND THE MAKING OF US

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Counting and the Course of Human Cultures

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For Jamie and Jude, who have enriched my life
in uncountable ways

CONTENTS

NUMBERS AND THE MAKING OF US

Prologue

ON THE SUCCESS OF OUR SPECIES

Survival is not easy. If you have ever ventured into an environment that has not been molded by contemporary society, you probably appreciated this fact quickly. Trekking through some tropical jungle on your own, for instance, this point is impressed on you with some severity. Aside from the discomfort of the sultry air and associated sweating (a poor adaptation in places with stifling humidity), not to mention such concerns as the various bacteria, viruses, insects, and more sizeable species potentially preying on you, you will find that the mere acquisition of water and food is onerous or downright impossible. If you ever have the chance to follow indigenous jungle-dwellers through the pliable Amazonian undergrowth, you will, if you are at all like me, become acutely aware of just how rapidly your surroundings could consume you were it not for the knowledge of those you are following. Juliane Koepcke, who famously survived the disintegration of her airliner thousands of meters above the Peruvian forest in 1971, startled the world when she survived the crash and lasted for more than 9 days alone in the jungle. As the teenaged child of biologists who worked in Amazonia, her knowledge of the surrounding ecology saved her life. Yet she was still unable to procure food during the whole of her ordeal and was eventually saved by members of a local riverine culture.

Most people in her position, isolated in the jungle, do not survive. The same is true of those lost in other unfamiliar pristine ecologies. The history of ocean navigation is littered with stories of explorers who were forced to rely on the local expertise of indigenous communities when stranded in new habitats. Televised "reality"-based depictions of individuals surviving in the wild without outside help are generally only made possible because the "solitary" survivor being filmed is provided with essential tools and supported by a team of producers who have prepared them in various ways for the environment in which they are "abandoned" along with their well-provisioned film crew. Humbling though it may be, you or I would likely die within a matter of days or, if luckier, weeks if left isolated in most of the world's ecosystems.[1]

More surprisingly, individual members of indigenous cultures often struggle in environments they know well, if they are accidentally isolated. Getting lost under the forest canopy may be comparatively less hazardous for those native to tropical jungles, for example, but it can still be a treacherous affair. I know of tribe members in Amazonia who have become perilously lost not far from their home village, only to barely survive or, in some unfortunate cases, to perish. Such cases drive home an important and often overlooked point: human survival is contingent on knowledge stored in the repository of culture, accessed through linguistic means. Daily, we rely on knowledge that is not really our own but can be easily extracted from the minds of others and has, in many instances, been brutally and often randomly acquired over the course of millennia. Consider some examples from your own culture: you did not need to invent the car, or indoor heating, or the most efficient method for filleting a chicken breast—you inherited such technologies and behaviors. You modeled your actions after others and were constantly taught your behaviors, either formally or informally, via language. The bulk of our daily activities, in-

cluding those related to fundamental processes, such as eating and sleeping, are entirely dependent on ideas that we absorbed from those around us, who in turn absorbed them from others. While certain needs are biologically determined, our approach to handling those needs is constructed by our native culture. Nearly every material and behavioral invention that facilitates your life, from the toothbrush to shaking hands, was innovated by another human or set of humans. When it comes to ideas, we inherit much more than we innovate. And the same could be said of members of cultures radically different from our own. Hunters in New Guinea do not need to invent bows and arrows as the need arises—they inherit that technology through teaching and mimicry. Each generation of any culture builds on the knowledge of the previous ones, often acquired through accidental discoveries that may have followed painful or deadly events. For instance, bows and arrows and other basic hunting implements were not invented in one fell swoop. They evolved over the course of centuries as hunters gradually came to realize the life-saving advantages of some forms of bows and arrows over others, for particular purposes.[2]

Our increasingly refined means of survival and adaptation are the result of a *cultural ratchet*. This term, popularized by Duke University psychologist and primatologist Michael Tomasello, refers to the fact that humans cooperatively lock in knowledge from one generation to the next, like the clicking of a ratchet. In other words, our species' success is due in large measure to individual members' ability to learn from and emulate the advantageous behavior of their predecessors and contemporaries in their community. What makes humans special is not simply that we are so smart, it is that we do not have to continually come up with new solutions to the same old problems. We know what has worked in the past, though we do not necessarily know why it has worked in the past. Just because you can reheat a burrito does not mean you have the slightest notion

of how to design a microwave or the electrical grid that enables its usage.[3]

The importance of gradually acquired knowledge stored in the community, culturally reified but not housed in the mind of any one individual, crystallizes when we consider cases in which entire cultures have nearly gone extinct because some of their stored knowledge dissipated due to the death of individuals who served as crucial nodes in their community's knowledge network. In the case of the Polar Inuit of Northwest Greenland, population declined in the mid-nineteenth century after an epidemic killed several elders of the community. These elders were buried along with their tools and weapons, in accordance with local tradition, and the Inuits' ability to manufacture the tools and weapons in question was severely compromised. This and other knowledge loss subsequently impaired their efforts to hunt caribou and seals and to harvest cold-water fish. As a result, their population did not recover until about 40 years later, when contact with another Inuit group allowed for the restoration of the communal knowledge base. In the course of human history, other cultures have died off completely due to analogous degradations of their survival-related know-how or because of the loss of basic material technologies that could not be easily replicated.[4]

Such cases directly contravene the popular, some would say mythologized, notion that humans excel simply because we are inherently smarter than other species. It turns out that this idea is poorly supported. While we are obviously smarter than other species and do have a high encephalization quotient (large brains for our body size), in some ways our innate cognition is not as advanced as we once assumed. Many of our distinguishing intellectual attributes are not genetically hardwired but learned in culturally dependent ways. While natural selection has undoubtedly yielded remarkable human brains, what is really most striking about our species is what

we have managed to do with those brains since the advent of culture. In this book I join the crescendoing chorus of anthropologists, linguists, psychologists, and other *ists* who emphasize this point. These scholars stress that culturally dependent innovations like language initiated a cognitive and behavioral revolution in our species. I suggest in this book that a set of conceptual tools called "numbers"—words and other symbols for specific quantities—is a key set of linguistically based innovations that has distinguished our species in ways that have been underappreciated. Numbers are, we shall see, human creations that, like cooking, stone tools, and the wheel, transformed the environments in which we live and evolve. While anthropologists and others have long been enamored with highlighting such inventions and their role in changing the script of the human story, the role of numbers has received insufficient attention in the past. The motivation for that inattention is simple: we are only now beginning to appreciate the extent to which the tools called "numbers" have reshaped the human experience.

PART 1

Numbers Pervade the Human Experience

1

NUMBERS WOVEN INTO OUR PRESENT

How old are you? From an early age, the answer to that question is literally at your fingertips. And it probably took only a fraction of a second for you to come up with an answer. Could there be an easier question, really? Many facets of your life are filtered by the number of your years. Can you drive a car by yourself? Well, it depends on how many years you have lived. Are you pleased with what you see in the mirror? That likely is influenced at least somewhat by your age, and what you expect to see in the mirror. Should you have a more fulfilling occupation? Hard to answer without knowing your age. The response to these and many other questions, which strike at the core of your identity and your day-to-day experience, can really only be stated if you know the answer to that first simple question. That question is undeniably meaningful to people in our own cultural matrix.

Yet, remarkably to those of us who attribute so much significance to our age, that same question is meaningless to members of some other cultures. This is not simply because members of such cultures fail to keep track of the earth's revolutions around the sun, but because they do not have the means of precisely quantifying such revolutions. In other words, they do not have numbers. Among the Amazonian indigenes known as the Munduruku, for instance,

there are no precise words for numbers beyond 'two.' In the case of their Amazonian counterparts the Pirahã, no number words of any sort are used, not even for 'one.' How then could the "how old are you" question be answered by speakers of these languages? Or what of other number-based questions that, to most of the world's people, also get at basic aspects of life? Consider a few more examples: What is your salary? How tall are you? How much do you weigh? In a world without numbers, such questions are useless—unaskable and unanswerable. These questions and their potential responses cannot be formulated, at least not with any precision, in anumeric cultures. And for much of the history of our species, all human cultures were anumeric. Numbers, the verbal and symbolic representations of quantities, radically transformed the human condition. In this book I explore the extent of that transformation, which has been remarkably recent. I focus on the transformative power of verbal numbers but also examine the role of written numbers. For terminological clarity, I usually refer to verbal numbers simply as *numbers,* and reserve the term *numerals* for written numbers. When referring to the abstract quantities described by numbers, I use symbols like 1, 2, 3, 4, and so forth.

During the past decade, a flurry of research has been done on numbers and numerals by archaeologists, linguists, psychologists, and others. From that research, a new story of numbers is beginning to take shape, a story that is told in this book. In short, it goes something like this: Despite what we once thought, numbers are not concepts that come to people naturally and natively. While quantities and sets of items may exist independently, apart from our mental experience, numbers are a creation of the human mind, a cognitive invention that has altered forever how we see and distinguish quantities. This notion is perhaps unintuitive to many of us who have lived our entire lives with numbers, having them coaxed into our mental experience from infancy. Yet, like another key

interrelated symbolic innovation of our species—language—numbers are in fact a culturally variable creation. Unlike language, however, numbers are absent in some of the world's populations. They are an innovation that indelibly impacts how most, but not all, people construe much of their daily experience. This indelible impact is at the core of the story this book tells. We will examine the way that numbers, one of the key inventions in the course of our species' history, served as a sort of flint stone that ignited the human timeline.

This story involves a lot of pieces, and later in this chapter I outline the way this book attempts to step from one piece to another, along a coherent path toward a newly formed conclusion. But before we talk about those pieces, I should exemplify what I mean when I say that numbers transformed the human experience. Perhaps the best way to do that is to examine further how we perceive the passing of time. I have noted that, without numbers, you obviously cannot label the quantity of the earth's trips around the sun since your birth. But maybe, you might counter, you could still have some sense of how old you are. You could know you were born before your sister and after your brother, for example, so you could know you are older than the former and younger than the latter. And you could recognize the changes of seasons and appreciate that you have lived through previous seasonal cycles. So you could at least know you are many years old, and perhaps know that you have experienced comparatively more or fewer years than your contemporaries. Yet, as we will see in our discussion of anumeric peoples in Chapter 5, such a sense of age is vague if one does not have recourse to numbers. The role of numbers in our temporal perception is more apparent, though, when we consider the passing of time at its most basic level—apart from how we enumerate years.

This consideration requires a brief digression into our general understanding of time. In some ways, time is a difficult notion to

grasp as it is inherently abstract. What does it mean to perceive or feel time? Well, it turns out, it depends on whom you ask and what culture they are from, or which language they speak. Recent research has demonstrated that time is conceived of in disparate ways across some populations. Next, I address some of this cultural variation, and then I will suggest that numbers have played an ineffable role in shaping the culturally variable experience of time.

We often talk about the 'passing' of time or of time 'passing by.' In fact I have done so in preceding paragraphs, and I doubt you considered such phrasing unusual. We also speak of time moving 'slowly' or 'quickly,' but clearly all these manners of speaking are metaphorical. Time does not really move, nor do we move through it. Cognitive scientists established some time ago that humans have a pervasive tendency to utilize concrete things, such as objects moving spatially, to metaphorically describe abstract aspects of our lives, like time. So we can talk about the 'movement' of time, or conversely about 'going through' a tough time, or of 'seeing' a difficult time 'ahead,' or of our inability to go 'back' to the past, or of choosing the right career 'path,' or of facing a fork in the 'road' of our lives, and so on. For speakers of English and many other languages, there are countless expressions that reflect and reify spatial interpretations of time. And most prominent among these metaphorical orientations is the one that pervades the examples just given, in which we face the future as time passes through us. It turns out, though, that for speakers of some languages, time does not work this way. For speakers of Aymara and several other languages, the future does not lie in front of the speaker. In fact, for the Aymara the future lies behind the speaker, while the past is located metaphorically in front of the speaker. This orientation is evident in various expressions about time and in the hand gestures fluent Aymara speakers make when talking about past and future events. (Arguably, such a metaphorical orientation maps more directly onto

the human experience since we can already 'see' what has happened in our past.) So, some humans perceive the 'movement' of time in a manner that seems diametrically opposed to the way we describe it and perceive it.[1]

The malleable spatial basis of temporal thought is further evident when we consider another way in which we can metaphorically depict time, namely, as moving from left to right along a measurable line. In our culture and others, there are myriad ways in which time is depicted as such. These include calendars, the progress bars on Netflix and YouTube, timelines in history books, and so forth. And robust experimental evidence suggests that such default symbolic practices impact how we perceive time. For example, when Americans are given a set of pictures depicting events at different stages (for instance, pictures of a banana being peeled and eaten) and are asked to orient those pictures from first to last, they typically place them in a left-to-right order so that the earlier images are closer to the left side of their own body. When members of some other cultures are given the same task, however, the ordering changes. Recently linguist Alice Gaby and psychologist Lera Boroditsky found that, in the Thaayorre culture on the Cape York Peninsula, people order the pictures not from left to right, nor from right to left (a pattern that surfaces in some cultures). Instead, they orient the pictures according to the trajectory of the sun, with earlier images being placed toward the east and later ones toward the west, regardless of the direction the person organizing the images is facing.[2]

Such findings reflect an important point: How we think about time is largely a matter of cultural and linguistic practice. And here is where numbers come into the story of how we make sense of this fundamental facet of our lives, because numbers clearly impinge on how we think about the 'movement' of time. Whether we think of time as passing through us or as moving along a timeline in front

of us, its 'movement' is divisible and countable. Think again of progress bars in online videos and how numbers (denoting minutes and seconds) track the icon that represents the moment being displayed in the video. In fact, numbers are ubiquitous in spatial, symbolic representations of time like left-to-right calendars and timelines. This number-centric conceptualization of time arguably governs our lives.

What time is it? For me, as I write these words, it is 10:46 A.M. on the east coast of the United States. Since it is that time of day, I am in my office, at my desk, rather than at home or some other place. But what does that time really mean? Well, it means it has been ten hours and forty-six minutes since midnight, sure, but that is a tautological restatement. What are hours? What are minutes? In truth, they do not exist apart from our mental and numerical experience. They are simply an arbitrary means of quantifying our existence, of dividing the metaphorical passing of time into discrete units. They are an indication of the fact that humans at some point chose to quantify time, to number moments of experience. Time may be real, existing apart from our own experience, but hours and minutes and seconds exist only in our minds, as a way to engage with the world. This means of engagement is itself due to particular linguistic and cultural traditions. Such time units as hours, minutes, and seconds are actually the detritus of ancient number systems. These units are really just linguistic vestiges of extinct civilizations.

Consider the division of each of the earth's rotations, each day, into 24 hours. Why is each day so divided? There is no astronomical motivation for this division, after all, and we could in theory have any random number of hours per day. But our time-keeping system owes its existence in large part to a tradition begun by the ancient Egyptians, who developed sundials more than 3,000 years ago. Those sundials were designed to partition the daylight into

twelve equal portions. This twelve-fold division was simply a by-product of the Egyptians' choice to divide the daylight in a culturally appropriate manner, as measured by shade along sundials. The choice allowed for ten divisible units of sunlight from sunrise to sunset, a natural choice since ancient Egyptian had a decimal number system like our own. Yet the sundial creators also added a unit each for dawn and twilight, the periods of the day that were not dark but in which the sun was not visible over the horizon. The simple decision of the Egyptians to divide daylight in such a manner yielded units of time based around the number 12, giving days a duodecimal feel. As we will see in Chapter 3, there are many bases in the world's spoken number systems, and duodecimal systems are pretty uncommon (and somewhat confusing to many people familiar with, say, decimal systems). Yet, because of the choice made by ancient Egyptian timekeepers, our language and thought about time are based in large part on a duodecimal-like system. This system is now firmly ingrained in our lives and enforces a certain perspective on our days. The existence of twelve-hour nights is also due to the Egyptians, as is, more indirectly, the 24-hour day / night cycle so familiar to us all. The latter system was more formally codified by Greek astronomers in the Hellenistic period, though hours of an exact and equal duration could not be appealed to until precise time-keeping mechanisms were invented. (The pendulum clock, a key innovation in time-keeping, was not created until the mid-seventeenth century.) Ultimately, then, the existence of hours is a historical accident. Had the Egyptian sundials originally separated daylight into tenths instead of twelfths, we would have ten major time units per day and night, respectively. The earth's rotations would be divided into twenty 'hours.'[3] In fact, a decimal-based time-keeping system was implemented in France immediately following the revolution, but the system failed to catch on due to the cultural entrenchment of hours and minutes. It is apparently easier

for a nation to dethrone a monarchy and decapitate a sizeable portion of its citizenry than to reorient itself to new time units.

Minutes and seconds are also the result of culturally and linguistically contingent decisions made long ago. These units of time owe themselves to the sexagesimal (base-60) system employed by Babylonians and, before them, by Sumerians. These cultures appear to have been the first to use such a base for astronomical calculations, for reasons that remain nebulous. Some believe the sexagesimal system gained prominence in Mesopotamia because it is neatly divisible by 1–6, as well as by 10, 12, 15, 20, and 30. Others think such base-60 systems likely arose because humans have five digits on one hand to count the twelve joints on the nonthumb fingers of the other hand (and $5 \times 12 = 60$). Regardless, sexagesimal systems are not common. They have only developed a few times during the history of the world's languages. Yet the sexagesimal nature of the Babylonian counting system is the reason minutes and seconds last as long as they do—because those are the units of time you arrive at if you divide hours and minutes, respectively, by sixty. People can now rely on independent metrics to define seconds, for instance the duration of a predefined number of energy fluctuations in a cesium atom. This definition serves as the standard of the atomic clock. But such a metric was chosen only because it closely approximated the length of traditional seconds that were merely a by-product of an ancient number system that yielded an effective but arguably unwieldy means of referring to time.

In sum, our construal of time is impacted by the metaphorical mapping of time onto space. Crucially, though, that space-based view of time is quantified in ways that are completely dependent on the existence of numbers. More specifically, this quantification is dependent on the characteristics of number systems once used in places like ancient Babylon. How we think about time—in discrete quantifiable units of hours, minutes, and seconds—is due to

the features of extinct languages and cultures, features with vestiges in our contemporary lives. These vestiges continuously orient how we organize our everyday experience. So ancient numbers with eccentric characteristics continue to shape the way we experience time, this abstract yet fundamental part of life. Our lives are, after all, governed by hours, minutes, and seconds. Yet time does not actually occur in these or any other discrete units. The segmentation of time into quantifiable units is truly a figment of the human mind.[4]

This discussion of the role of numbers in shaping our perception of time is illustrative of how powerfully numbers, and differences among number systems, can impact our cognitive and behavioral lives. Yet we will see during the course of this book that the invention of numbers impacted our lives, and the human narrative more generally, in many other equally profound ways. Before talking about those ways, though, some relevant background on our species is in order. This background is essential to, and intimately linked with, the story of numbers that this book tells.

Young *Homo sapiens*

Our capacity for measuring the passing of time is quite handy when discussing the recent origins of *Homo sapiens.* Numbers help depict just how young our species is: The universe is about 13.7 billion years old, the earth about 4.5 billion, and eukaryotic life about 3 billion. The emergence of primates occurred sometime around 65 million years ago. The fossil record suggests that hominins, including the ancestors of humans, have lived for only about a tenth of that time. Much debate remains about when exactly we, modern humans, first emerged, but we have definitely been around at least 100,000 years. Accepting the latter figure for the moment, this means we have only existed about one year for every 130,000 the

universe has been around. This is an often unrecognized feature of humans: we are really, really young. Yet, despite our youth, we have in many ways shaped this planet on which we have been residing for such an insignificant fraction of its existence, particularly in the past few thousand years. Numbers, we will see, are a big part of how and why that happened.[5]

Extensive data demonstrate that *Homo sapiens* and its ancestral species evolved in Africa. Key components of our present physical characteristics began to take shape there, for instance the bipedalism first clearly evident in australopithecines—whose footprints from 3.7 million years ago are apparent in the volcanic ash in Laetoli, Tanzania. Larger brains also emerged in species like *Homo erectus* (about 1.8 million years ago) and *Homo heidelbergensis* (more than half a million years ago), species that managed to explore non-African continents but whose material record is not as suggestive of a dramatic cognitive leap forward, as in the case of *Homo sapiens.* This latter point hints at something crucial: human ancestors had relatively large brains, though not as large as our own, long before we arrived on the scene. Yet, despite their large brains, the behavior of our closest ancestral species was not nearly as remarkable when contrasted to other great apes. It bore little resemblance to that of modern humans or of *Homo neanderthalensis,* our sister species that lived in Europe for about half a million years—until its extinction was apparently accelerated by our arrival on that continent.[6]

So one reasonable way to frame the evolution of our species is as one of radical recent change. Sure, our lineage has been evolving for millions of years in ways that made us, physiologically, who we are today. Yet for most of that time our ancestors lived harsh, short lives, often serving as prey for larger African species. We did not always outcompete other species to the degree that we do now. I recently spoke with a fellow anthropologist, a paleoarchaeologist

INDEX