



Bamana Sand Divination: Recursion in Ethnomathematics

Ron Eglash

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Bamana Sand Divination

Recursion in Ethnomathematics

THE RELATIVELY NEW discipline of ethnomathematics has been motivated by its straightforward epistemological opposition to primitivism as well as its potential application to education and development (here entering into the more general “indigenous knowledge” framework). But because of these potent and direct applications, there has been less emphasis on theoretical development. In particular, there is little application of the move toward reflexive anthropology in ethnomathematics. This is not surprising, given that reflexive anthropology attempts to turn the Western gaze back on itself, disrupting realist claims through its portrait of ethnographic representation as a social construction. What possible point could there be to making the reflexive move in ethnomathematics? It is already hard enough to get anyone to believe accounts of topological theory woven in palm fronds; so why bother disrupting it? And since mathematics is never subjective, but rather the unvarying result of pure logic, what could possibly be “constructed” about it? Nevertheless, there are indeed good reasons for using reflexivity in ethnomathematics. In particular, there is reflexivity already present in many mathematical systems in the form of recursion. Through the example of Bamana sand divination, this essay will attempt to show how reflexive cultural analysis and recursive mathematics can be brought together.

Theoretical Background

Ethnomathematics is primarily the child of “non-Western mathematics” and “mathematical anthropology.” Non-Western mathematics (e.g., Raum 1938) traces its genealogy to the same reports of traders and missionaries that provided the origins of cultural anthropology, but rather than changing into an analytic

methodology, it maintained its descriptive emphasis in the transition to scholarly rigor. Its discursive trope is typically one of translation, with each example framed as a non-Western “version” of Western mathematics (such as the use of base-five counting systems). Mathematical anthropology, generally defined as mathematical modeling of social and material culture, could be said to begin with the early classificatory systems for kinship (e.g., Morgan 1871). The anthropological significance of this approach was soon opposed, however, by functionalists such as Bronisław Malinowski, who insisted that kinship is the result of “a host of personal intimate interests” and could not be “reduced to formulae” (1930:19).

Malinowski was quite willing to grant the epistemological status of science for certain types of indigenous knowledge (e.g., Trobriand outrigger technology) but carefully separated these analytic narratives from the real stuff of anthropological inquiry, warning that “there is no more fallacious guide to knowledge than language” (1925:78). At first one might think that structuralism would provide direct opposition to this notion, but here too there was a curious reticence to consider indigenous mathematical knowledge. Lévi-Strauss, for example, used indigenous botanical classificatory systems as illustrations of the epistemological equivalence between West and non-West, but reserved the more complex algebraic analysis of kinship systems as an anthropological understanding. Later refinements of mathematical anthropology (such as Kay 1971) expanded this analytic modeling to a variety of social phenomena and to very complex mathematical systems but maintained its location in the mind of the anthropologist. Aside from anthropological tradition, the reasons for this distancing may also be related to the Platonic realism of the mathematics subculture. For mathematicians in the Euro-American tradition, truth is embedded in an abstract realm, and these transcendental objects are inaccessible outside of a particular symbolic analysis.

RON EGLASH is a lecturer in the Division of Comparative Studies in the Humanities, Ohio State University, Columbus, OH 43210.

Thus the two parent disciplines of ethnomathematics showed a sort of symmetrical lack. Non-Western mathematics did not (with the exception of the empires of ancient Chinese and Hindu civilizations) have the abstract complexity of mathematical anthropology, and mathematical anthropology could not credit its subjects of inquiry with its own complex discoveries. The two were brought together through the device of cultural relativism.

In Claudia Zaslavsky's seminal *Africa Counts* (a title that conveys the oppositional stance of ethnomathematics), a somewhat vague collection of patterns—art, games, economics, and so forth—took on a new epistemological status. They were not framed as a “first step” in a universal historical progression, nor was the complexity revealed by analysis implied to be the sole property of the mathematician-anthropologist. There remained a question of balance between the complexity of the analysis and the attribution of intentionality on the part of the Africans, but this was a useful tension that opened the possibilities for indigenous math systems without dissolving them into subjectivity.¹

Similar ideas have been developed independently by several African scientists and mathematicians. In Senegal, for example, physicist Christian Sina Diatta has lectured on the use of Jola concepts in mathematical modeling, and Sakir Xiam has explored mathematics pedagogy in Wolof (see also Njock 1979). Work in various areas of the world has expanded this synthesis, providing complex mathematical analyses for a variety of indigenous patterns and abstractions while pushing the location of mathematical thought toward the local culture.²

At the same time, however, researchers in science and technology studies (STS) have been looking in the direction of Western mathematics as a possible location of cultural thought. STS has been quite successful in demonstrating the cultural influences in a variety of the “soft” sciences (see, for example, Gould's [1981] history of racism and sexism in biology), but the task has been increasingly difficult as we look toward the “hard” science end (thus mathematics signified the extreme in difficulty). This problem was somewhat mitigated by the move from an analysis of cultural influence in science to portraits of cultural construction (the “strong programme” of Bloor [1976]). Cultural construction no longer maintained an inner core of science as a neutral or value-free institution whose outer edges were biased by social influence. Rather, it held that both failure and success in science were the result of social constructions of knowledge, and that logical certainty could still be multiple (as Bloor [1976] showed in his discussion of mapping the historical alternatives for definitions of a polyhedron). In addition to these new social analyses of mathematics (see Restivo et al. 1993), the mathemati-

cians themselves have recently been an active force in considering the social aspects of their subculture, probably because the widespread assumption that mathematics is culture-free allows them to relax a guard that must be defended in other sciences.³

Thus the anthropology of mathematics—which, ideally, would not be using the *ethno-* prefix to designate non-Western societies (especially given the undertheorized status of white ethnicity)—finds itself split between its non-Western subject in ethnomathematics and its Western subject in STS. Ethnomathematics looks at a society previously framed as distant from science, and shows that this culture does indeed have mathematical content. STS analyzes a mathematical practice previously framed as culture-free and shows its basis in social process and cultural meaning. To fully bridge this gap is beyond the scope of this essay, but the following example may be helpful in thinking about how a recursive exchange between the two approaches might be beneficial to a broader understanding of the relationship between culture and mathematics.

African Epistemology and Divination

Comparisons of Western technoscience and traditional knowledge systems are nothing new in the discourse of African epistemology. Anthony Appiah (1992) provides an extensive discussion of this intersection, starting with ethnophilosophy. His analysis weaves between the positions of Kwasi Wiredu (1979), who critiques the focus on comparison to Western science rather than religion (noting that it leaves the superstitions and folk philosophies of the West unexamined), and Paulin Hountondji (1983), who argues against any mimetic comparison, suggesting that ethnophilosophy and its allies are dressing European motivations in autochthonous garb. Like V. Y. Mudimbe's (1988) Foucaultian discourse analysis and Paul Gilroy's (1993) fractal history, Appiah's dialectical contour maps African epistemology as a historical process rather than an object of strictly pre- or post-Western presence.

Divination enters Appiah's analysis through Edward E. Evans-Pritchard's classic Azande study (1937), showing that the supposedly self-limiting system of explanation for failures in Azande magic are quite similar to the theory-laden observation and resistance to new paradigms described in STS. Appiah does not, however, allow either technoscience or the Azande knowledge system to be reduced to a closed feedback loop, citing Barry Hallen's (1977) evidence for satisfaction of Karl Popper's (1962) “critical reflection” criteria in the work of a Yoruba diviner. A similar rejection of the “closed world” portrait underlies the recent collection on African divination studies edited by Philip Peek, who notes



Figure 1

Baoule door carving. Vogel (1977) records this carving as an iconic representation of social forces in balance; thus it can be viewed as analogous in both structure and application to the Western negative feedback loop diagram. Photo courtesy IFAN, Dakar.

that Evans-Pritchard himself was interested in possibilities for a more reflexive comparison of knowledge systems (Peek 1991:7–8). In the case of ethnomathematics, the issue is not the applicability of negative feedback as a model for the traditional knowledge system, but rather the ways that traditional knowledge might create feedback models (Figure 1).

Bamana Divination Pedagogy

My study took place in Dakar, Senegal, where the local Islamic culture credits the Bamana (also known as Bambara) with a potent pagan mysticism. As in many other areas of Africa, the clash between Islamic economic hegemony and animist spiritual authority is a complex dynamic (see Masquelier 1993). There is a more subdued syncretism with Islam within Bamana culture itself, which organized the states of Segou and Kaarta under animist rule from 1712 to 1862, and even after political defeat maintained strong resistance to Islam in many areas of the Mande diaspora.⁴

The strategy of “othering” ranges from repression (Fanon 1963) to resistance (Taussig 1993); here it was an important part of the professional identity of the diviner. Rudolph Blier (1991) and Elizabeth Colson (1966) suggest that an alien status allows diviners to be seen as more impartial. Individuals from the Wolof ethnic majority seemed to frame the outsider status as indicating powers from outside the norm (and hence outside the natural). Almost all diviners had some kind of physical deformity—“the price paid for their power”—and these were displayed rather than hidden.⁵ Dress and mannerisms also served to distance them from the mainstream Wolof culture. (One woman had hands and feet dyed with indigo.) They were quick to show me their Malian passports, which were presented as official proof of their Bamana identity.

At the site of the study there were six diviners, usually with no more than four present at any one time. All were located at the edge of the very urban Marche Sandaga, on a quiet street between a dump for construction materials and some shipping companies. The construction material was put to good use by the sand diviners. Both men and women used cowrie-shell divination, which concentrated on iconic patterns discerned in the tossed shells, allowing complex narratives to build up around a putative future. I was a bit of a disappointment to the cowrie-shell diviners, who found my mathematical questions to be a distraction from their efforts to entice me to pay them for extra services to guarantee good fortune. One pointed to his deformed foot as an indication of the potential dangers.

The sand diviners were somewhat more flexible, particularly when using the palm liqueur and marijuana, which improve their occult vision. Marijuana is illegal in Senegal, but the police officers’ fear of being cursed allows diviners to smoke with impunity. They were also much more interactive than the cowrie-shell diviners, often recording and discussing the results of their work on scraps of paper.⁶ One sand diviner, who was always accompanied by a friend in urban dress, seemed quite willing to teach me his system, suggesting that it “would be just like school.”

James Clifford (1988) mentions the relationship of student-teacher as one of the many possible choices for ethnographic interactions. It did not necessarily seem optimal to me, but it was indeed the relation of choice for the diviner (perhaps because it helped cover my status as an economic resource). The friend in urban dress did not do divination himself, but he was introduced to me as “a professor of his people” and held authority over the entire group. The first few sessions went smoothly, with the diviner showing me a symbolic code in which each sign, represented by a set of four vertical dashed lines drawn in the sand, stood for some archetypical concept (such as traveling, desire, or health) with which they assembled narratives about the future. But when I finally asked how they derived the symbols—in particular the meaning of some patterns drawn prior to the symbol writing—they just laughed at me and shook their heads. “That’s the secret!” My offers of increasingly high payments were met with disinterest. Finally, I tried to explain the social significance of cross-cultural mathematics. I happened to have a copy of Linda Garcia’s *Fractal Explorer* (1991) on me and began by showing a graph of the Cantor set, explaining its recursive construction. The head diviner suddenly stopped me, snapped the book shut, and said, “Show him what he wants!”

Recursion and Rosicrucian Jews

For the mathematics subculture of 1877, Georg Cantor’s transfinite set theory was as much an intrusion of the supernatural as any Bamana presence is in Dakar. Infinity had been banished by Aristotle on the basis that it was “self-annihilating” (infinity + infinity = infinity) and therefore could only be a potential. Although the introduction of calculus in the second half of the 17th century brought attention to the concept of the “infinitesimal” (revived from its Greek banishment in 1615 by Johannes Kepler’s *Stereometria*) and to the convergence to a limit as infinity is approached, infinity as a unitary mathematical object was strictly forbidden. Cantor’s rigorous foundation for an infinite set, classes of infinity, and their relation to the real-number continuum made possible the impossible, destroying the Aristotelian distinction as a difference between legitimate and illegitimate mathematics (Maor 1987).

The Cantor set (Figure 2) was his visualization of transfinite number theory. It shows the interval of zero to one on the real number line and indicates that the number of points are not denumerable, that is, the number is greater than infinity. The set (which has a positive measure but zero dimension) was a prototype for other recursive set constructions; in the late 20th century these would become the basis for the computational modeling of natural self-organizing systems in Benoit Mandelbrot’s fractal geometry (1977). But at the time, applied mathematics was far from Cantor’s mind.

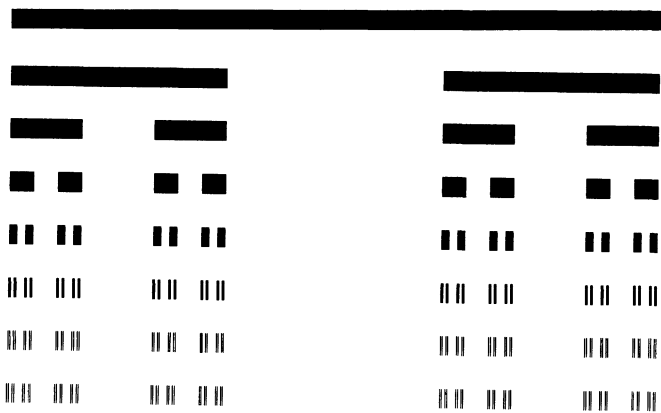


Figure 2
The Cantor set. From Mandelbrot 1977.

His real fascination was in theological implications: the increasing classes of infinity he discovered seemed to point toward a religious transcendental. Cantor’s biographers differ greatly on the cultural significance of this point. Eric T. Bell felt that Cantor’s Jewish ethnic origin ruled his life and made several remarks about the inheritance of personality traits—particularly disturbing in

light of his remarks on Cantor’s archrival, the Jewish mathematician Leopold Kroneker:

There is no more vicious academic hatred than that of one Jew for another when they disagree on purely scientific matters. When two intellectual Jews fall out they disagree all over, throw reserve to the dogs, and do everything in their power to cut one another’s throat or stab one another in the back. [Bell 1937:562–563]

In a scholarly masterpiece on Cantor, biographer Joseph Dauben flatly declares that since Cantor’s mother was Roman Catholic, “in fact, Cantor was not Jewish” (1979:i). Nazi scholars solved their own worries by spreading a story that Cantor was found abandoned on a ship bound for St. Petersburg (Grattan-Guinness 1971:352).

Actually Cantor’s Jewish identity was quite complex. His family had indeed converted to Christianity, but he was well aware of his heritage. He referred to his grandmother as “the Israelite” and wrote a religious tract attempting to show that there was no Virgin birth and that the real father of Jesus Christ was Joseph of Arimathea. Cantor eventually joined the Rosicrucians, whose mystical-scientific approach to a supposed Egyptian origin for all religions probably appealed not only to his intellectual interests but also to his syncretic ethnicity. Cantor chose a Hebrew letter as his new symbol. The aleph, the beginning of the alphabet, was used to represent the beginning of the nondenumerable sets. While his biographers argued Jew or not-Jew, off or on, zero or one, Cantor himself proved that the continuum from zero to one cannot be delimited by any subdivision process, no matter how long its arguments.

Recursion and Bamana Sand Divination

As Figure 3 indicates, it is not surprising that the diviners reacted so strongly to the Cantor set. The divination begins with four horizontal dashed lines, drawn very rapidly, so that there is some random variation in the number of dashes in each. The dashes are then connected in pairs, such that each of the four lines are left with either one single dash (in the case of an odd number) or no dashes (all pairs, in the case of an even number). The narrative symbol is then constructed as a column of four vertical marks, with double vertical lines representing even dashes and single representing odd. At this point the system is very similar to the famous Ifa divination: there are two possible marks in four positions and so 16 possible symbols. Unlike the process in Ifa divination, however, the random symbol production is repeated four times rather than two. The difference is quite significant. Each of the Ifa symbol pairs is interpreted as one of 256 possible Odu, or verses. The Ifa diviner must memorize the Odu; hence four symbols

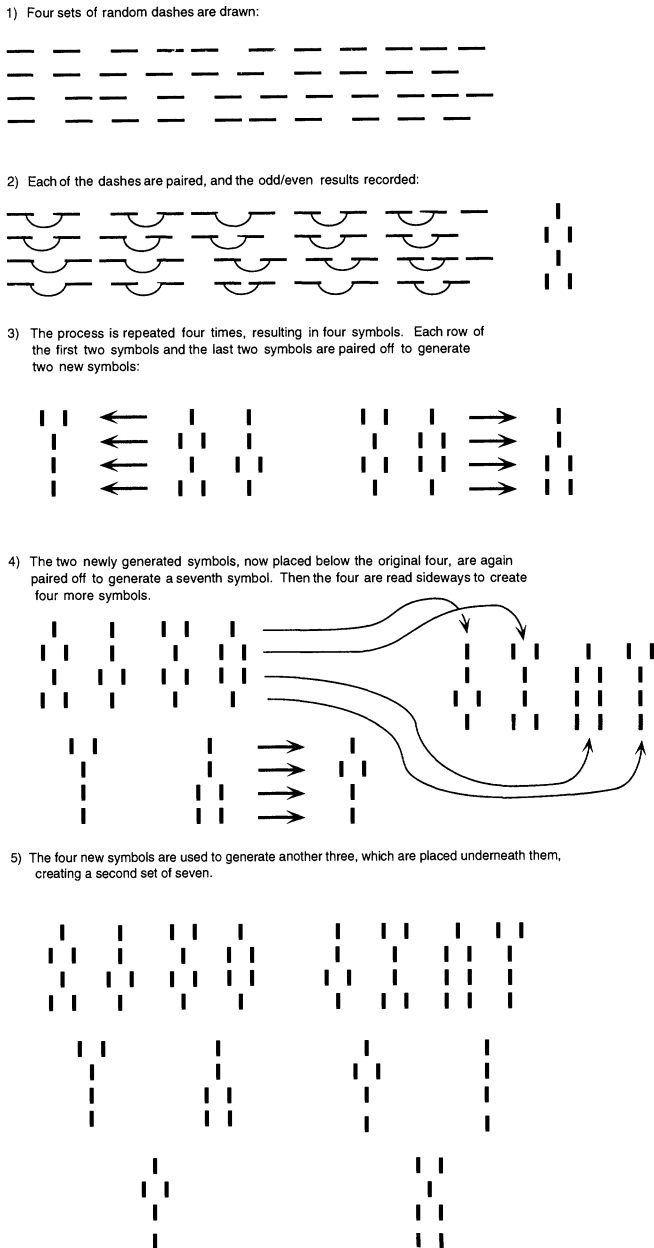


Figure 3
Bamana sand divination.

would be too cumbersome (65,536 possible verses). But the Bamana divination does not require any verse memorization; as we will see, its use of recursion allows for verse self-assembly.

Recursion is generally defined as any iterative mathematical function in which the output of each iteration is used as the input for the next iteration. In this case the function is addition modulo 2 ("mod 2"), the same simple even-odd distinction in the parity-bit operation that contemporary computer systems use to check for errors. There is nothing particularly complex about mod 2; in fact, I was quite disappointed at first

because its reapplication destroyed the potential for a binary placeholder representation in the Bamana divination. Rather than interpret each position in the column as having some meaning (as would our binary number 1001, which means one 1, zero 2s, zero 4s, and one 8), the diviners reapplied mod 2 to each row of the first two symbols and each row of the last two symbols. The results were then assembled into two new symbols, and mod 2 was applied again to generate a third. Another four symbols were created by reading the rows of the original four as columns, and mod 2 was again recursively applied to generate another three symbols.

The use of an iterative loop, passing outputs of an operation back as inputs for the next stage, was striking to me; I was at least as taken aback by the sand symbols as they had been by the Cantor set. It would be naive to claim that this was somehow a leap outside of our cultural barriers and power differences—in fact, that is just the sort of pretension that reflexive anthropology has been dedicated against—but it would also be ethnocentric to rule out those aspects that would be attributed to mathematical collaboration elsewhere in the world: the mutual delight of two recursion fanatics discovering each other. And the appearance of the symbols laid out in two groups of seven—the Rosicrucian's mystic number (not to mention the respective publication dates of Cantor and Mandelbrot in 1877 and 1977)—added some numerological icing on the cake.

The following day I found that the presentation had not been complete. There were an additional two symbols that were left out; these were also generated by mod 2 recursion using the two bottom symbols to create a 15th, and using that last symbol with the first symbol to create a 16th (bringing the total depth of recursion to 5). The 15th symbol is called "this world," and the 16th is "the next world"; so there was good reason to separate them from the others. But it may be that the emphasis was partly done for my benefit, as a bit of mathematical translation to better fit the Cantor set model.

The final part of the system—creating a narrative from the symbols—was still unclear, but I was assured that it could be learned if I carefully followed their instructions. I was to give seven coins to seven lepers, place a kola nut on a pile of sand next to my bed at night, and in the morning bring a white cock, which would have to be sacrificed to compensate for the harmful energy released in the telling of the secret. I followed all the instructions and the next morning was told to eat the bitter kola nut as they prepared the chicken, marking divination symbols on its feet with a blue Bic pen. A little sand was thrown in its mouth, and then I was told to hold it. There was no action on the part of the diviner; the chicken simply died in my hands.

While I was still a bit shaken by the chicken's demise (as well as a respectable buzz from the kola nut),

they explained the remaining mystery. Each symbol has a “house” in which it belongs—the position of the 16th symbol is “the next world”—but in any given divination most symbols will not be located in their own house. Thus the symbol for desire in the house of travel indicates a desire for travel, and so on. Obviously this still leaves room for creative narration on the part of the diviner, but the beauty of the system is that no verses need to be memorized or books consulted; the system creates its own complex variety.

The most elegant part of the method is that it only requires four random drawings; after that the entire symbolic array is quickly self-generated (a timesaving device that allows more clients; see Meyer 1991 on client overload). A similar system for self-generated variety was developed as a model for the “chaos” of nonlinear dynamics by Marston Morse (1892–1977). Morse begins by counting from zero in binary notation: 000, 001, 010, 011, 100, and so on. He then takes the sum of the digits in each number— $0 + 0 + 0 = 0$, $0 + 0 + 1 = 1$, and so forth—and finally mod 2 of each sum. The result is a sequence with many recursive properties but also endless variety. Morse did the same “misreading” of the binary number as did the Bamana—although he did not have an anthropologist scowling at him for ignoring place value—and he did it for the same reason: combined with the mod 2 operation, it maximizes variety.

Geomancy

In Western culture the dichotomy between “hard,” or quantitative, science and “soft,” or qualitative, science has created a spectrum of status based on claims to objectivity. When I have described Haraway’s study of primatology to Western physicists, for example, they usually reply, “Well of course, I’ve always thought biology is too subjective; that’s why I became a physicist.” But mathematics occupies a special position at the end of this spectrum; in many ways it is a “closed world” operating only by its own axioms, and perhaps that is why divination receives less attention as scientific knowledge. This is particularly unfortunate in the cross-cultural comparison of ideas such as chance and determinism, since the recent discovery of deterministic aperiodicity—as framed by nonlinear dynamics—maps quite well onto the traditional African conceptions of tricksters and related forms of causal unpredictability.

Evans-Pritchard (1937) noted that the Azande ranked the validity of divination methods in proportion to what he saw as their probabilistic variation, and similar observations are made by René Devisch (1991). Peek (1991) notes that Ifa diviners vary in their use of correlations between the two sides of the divination chain, which would also introduce control over prob-

abilistic variation. Variations between chaos and order within individual divination sessions are also well documented. Rosalind Shaw (1991), for example, shows an intricate combination of mod 2 and mod 4 calculation with random casts in Temme divination, providing the semantic process with variations in both periodic-aperiodic and chance-deterministic oppositions.

In my reading of divination literature, I eventually came across the duplicate of the Bamana technique in Malagasy *sikidy* (Sussman and Sussman 1977) and the historical debate on its diffusion. The strong similarity of both symbolic technique and semantic categories to what Europeans termed *geomancy* was first noted by Etienne Flacourt (1661), but it was not until René Trautmann (1939) that a serious claim was made for a diffusion from the Arabic *ilm al-raml* (“the science of sand”) to European, West African, and East African divination techniques. This was supported in a detailed formal analysis by Robert Jaulin (1966). Stephen Skinner (1980) provides a well-documented history of the diffusion evidence from the first specific written record, a ninth-century Jewish commentary, to its modern use in Aleister Crowley’s *Liber 777*. Skinner’s most intriguing connection is the similarity between the geomancy of Raymond Lull and the design of Lull’s “logic machines.”⁷ But his orientalist perspective (a “lethargic” Africa is “woken by Islam”) makes the ultimate attribution to Arabic invention suspect.

The oldest Arabic documents (those of az-Zanti in the 13th century) claim geomancy’s origin through the Egyptian god Idris (the Arabic name for Hermes Trismegistus), and while we need not take that as anything more than a claim to antiquity, a Nilotic influence is not unreasonable. Wallis Budge (1961) attempts to connect the use of sand in ancient Egyptian rituals to African geomancy, but it is hard to see this as unique. Mathematically, however, geomancy is strikingly out of place in non-African systems.

Like other linguistic codes, number bases tend to have an extremely long historical persistence. Even under Platonic rationalism, the ancient Greeks held ten to be the most sacred of all numbers; the Kabbalah’s Ayin Sof emanates through ten Sefirot, and the Christian West counts on its “Hindu-Arabic” decimal notation. In ancient Egypt, on the other hand, base-2 calculation was ubiquitous, even for multiplication and division, and Claudia Zaslavsky (1973) notes archaeological evidence linking it to the use of doubling in the counting systems of sub-Saharan Africa. T. Kautzsch (1912) notes that both Diodorus Siculus and Ælian reported that the ancient Egyptian priests had a method of seeking truth through division by two. Doubling is a frequent theme in African divination and many other African knowledge systems, connecting the sacredness of twins, spirit doubles, and double vision with material

objects, such as the blacksmith's twin bellows and the double iron hoe given in bridewealth.

Moreover, the use of the addition modulo operation has an independent origin in Africa with the game that is variously termed *ayo*, *bao*, *giuthi*, *lela*, *mancala*, *omweso*, *owari*, and *soro* (among many other names). The game is played by sequentially placing counters in twin (or double twin) rows of cups (sometimes referred to as "houses"), and for large counter-cup ratios, addition modulo is required to calculate winning moves. Zaslavsky notes that it can be played as a game of chance by beginners, underscoring the relation between deterministic aperiodicity and our intuitive notions of randomness. Boards cut into stones, some of extreme antiquity, have been found from Zimbabwe to Ethiopia (see Zaslavsky 1973: figure 11-6). That the game, while of African origin, is known throughout East Africa under its Arabic name of *mancala* suggests that Skinner's linguistic basis for an Arabic origin of geomancy is less certain than it might at first seem.

The recursive aspects of Bamana divination can also be illuminated by comparison to geomancy's cross-cultural history. European geomancers like Raymond Lull, Robert Fludd, de Peruchio, and Henry de Pisis persistently replaced the deterministic aspects of the system with chance. By mounting the 16 figures on a wheel and spinning it, they maintained their society's exclusion of any connections between determinism and

unpredictability (see Porter 1986). The Bamana, on the other hand, seem to have emphasized such connections. On a video recording that I made of the Bamana divination, I later noticed that they had used a shortcut method in some demonstrations. (This may have been a parting gift, as the video was shot on my last day.) As first taught to me, when they count off the pairs of random dashes, they link them by drawing short curves. The shortcut method then links those curves with larger curves, and those below with even larger curves. This upside-down Cantor set shows that they are not simply applying mod 2 again and again in a mindless fashion. The self-similar physical structure of the shortcut method vividly illustrates a recursive process.

African divination can be elsewhere linked to recursion, as in Devisch's (1991) description of the Yaka diviners' "self-generative" initiation and uterine symbolism. But the Bamana represent recursion in other domains as well. Figure 4 shows a *chi wara* sculpture visualizing the cyclic iteration of living generations. Their cultural neighbors, the Dogon, are famous for a cosmology based on recursive nesting of the human form, and Bamana lamps and *merenkun* puppets sometimes feature a self-similar cascade of human shapes (see Figure 5). The architecture of the Sudanese area also makes use of self-similar structures (Eglash 1995a, 1995b; Eglash and Broadwell 1989), and Alexander Badaway (1965) found that a recursive numeric sequence was used to create such scaling in the construction of ancient Egyptian temples (such as the one at Karnak). Icons linking this architectural self-similarity to a self-generating cosmology, also represented by nested human forms, were used in ancient Nilotic civilizations (Figure 6).

Cantor and the Bamana

Before the 1970s, the standard analytic approach to Cantor and the Bamana would have been a mathematical portrait of Cantor's work and an ethnographic portrait of the Bamana. By including ethnomathematics and STS perspectives, we find a new array of causal explanations and meanings. In the STS view, Cantor's work cannot simply be the discovery of new mathematical objects, because its universal truths are also the result of his local cultural meanings. Conversely, an ethnomathematics view of the Bamana diviners would focus not on their local social semantics but on their work as mathematicians, as theorists of the universal. Whereas the pre-1970s approach set up a mathematics-versus-culture division, the more recent alternatives show that this division exists within each side of the divide. But there is no reason for stopping after only two iterations; if we allow for recursive subdivisions, then

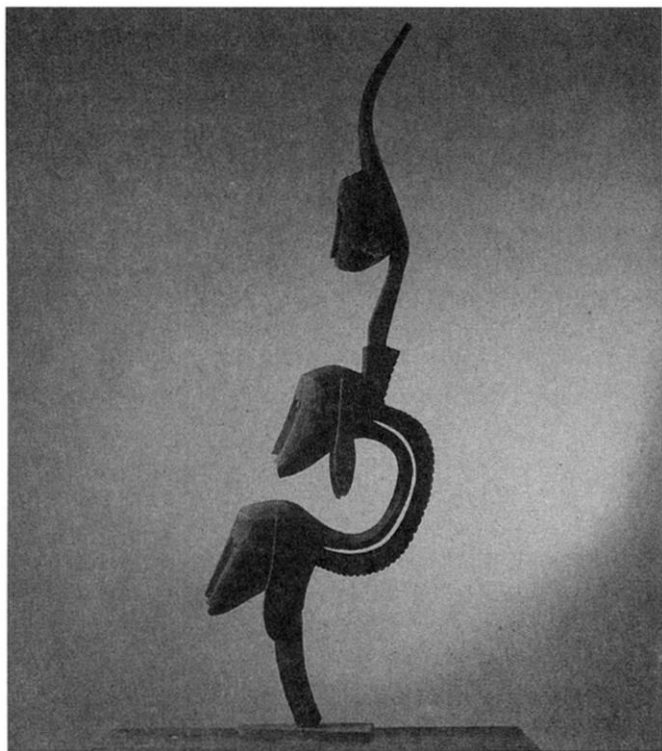


Figure 4

Recursion in the *chi wara*. The cycles of living generations are depicted as an iterative structure in the *chi wara* headdress symbolism.

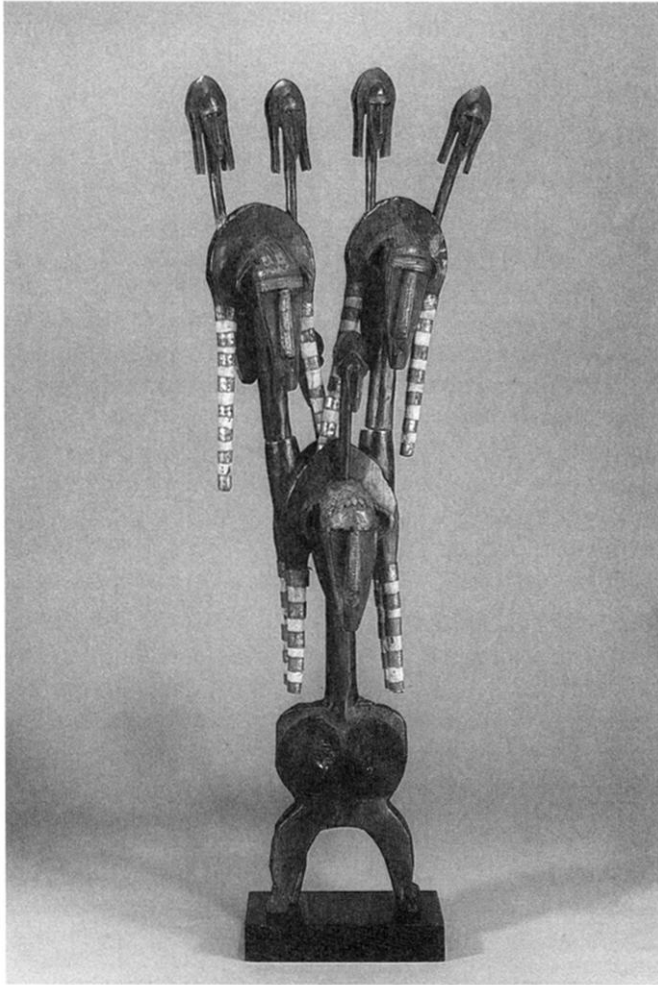


Figure 5

Scaling cascade in Bamana merenkun puppet representing multiple spirits (see Arnoldi 1977). The puppet is worn on the head, thus adding self-referential imagery to this scaling cascade. Photo courtesy the Indiana University Art Museum, Bloomington.

the two sides may begin to show some strong similarities.

The Cantor set and the double-seven configuration of the initial 14 divination symbols may have a superficial visual similarity, but the comparison only becomes mathematically significant if we hold one upside down. Cantor's problem was in taking the finite—a line of unit length—and demonstrating that it could be expanded beyond infinity. The diviners are faced with the infinity of possible futures and must show how they can be narrowed down to a predicted unity. It is clear that, while we can consider the diviners as theoreticians, their mathematics is driven by the performative requirements of their work. But European mathematicians must also gather clients and perform their theories; it was quite some time before Cantor was acknowledged as a legitimate mathematical actor. And while both

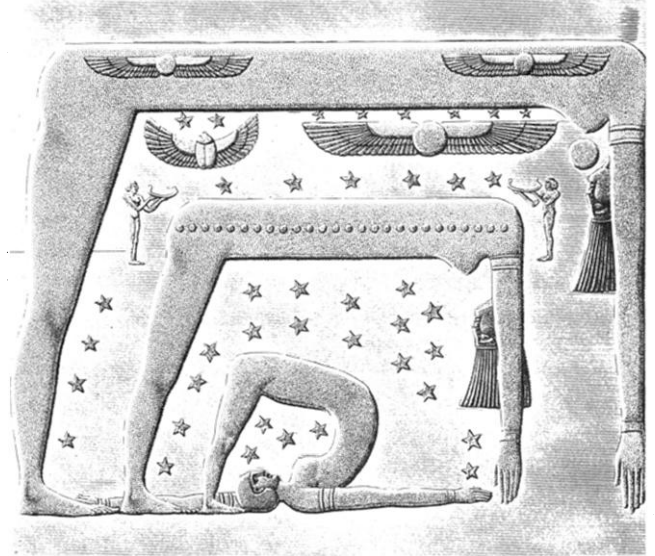


Figure 6

Recursive cosmology in ancient Egypt. From *Description de l'Egypte*, Paris, 1820.

Figure 7

The Cantor set in Egyptian capitals. This capital from an ancient Egyptian temple represents the lotus, symbol of the self-generating origins of life. From *Description de l'Egypte*, Paris, 1820.

mathematical systems are unified in their use of recursion—united through the universality of mathematical process—they are culturally linked as well. Indeed, given Cantor's Rosicrucian theology and the proximity of his cousin Moritz Cantor—at that time a leading expert in the geometry of Egyptian art (M. Cantor 1880)—it may be that an African concept of self-generated fecundity (as visualized in Figure 7, an ancient Egyptian representation of the lotus creation myth) is the shared origin of both the Bamana divination and transfinite set theory. Neither mathematics nor culture should be viewed as firmly fixed on the universal-local divide, for there are divisions within divisions never ending.

Notes

1. Significantly, the most direct statement in Zaslavsky's text concerning math and cultural relativism is in a quote from F. E. Chapman, an African American historian sentenced to life imprisonment for a robbery and murder when he was 19. A more diasporic view of mathematics in African cultures—for example, Malcom X on the numeric capabilities of his mentor in the numbers racket or on his own oppositional adoption of the generic symbol for the mathematical unknown—might reveal some wider implications for the power-knowledge relations of mathematics and society.
2. Ascher 1990; Closs 1986; Crump 1990; D'Ambrosio 1990; Gerdes 1994; Washburn and Crowe 1988; and others. See Crowe 1987 and Fisher 1992 for reviews.
3. Davis 1988; McCleary and McKinney 1986; Wilder 1981.
4. Imperato 1983; McNaughton 1988; Zahan 1974.
5. After giving a lecture on Bamana divination in the United States, I was approached by a mathematics faculty member who was quite taken by this phrase. "That's just like us!" he exclaimed. "We get the power of mathematics only at the cost of our social deformity as nerds."
6. They typically used computer printouts. This recycled paper was generally available but may have had particular significance for diviners due to the symbolics of computers in Africa; see Jules-Rosette 1990.
7. Since Lull's "logic machine" inspired Leibniz (about 1670) in his development of the modern binary code, Skinner's theory about the influence of geomancy on Lull would mean that the streams of ones and zeros running through every digital circuit, from alarm clocks to supercomputers, can trace their origins back to African divination.

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