African Influences in Cybernetics

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The problems of natural/artificial dualisms encountered by cyborgs are similar to those which plague activists and theorists in the long historical battles against racism. Primitivist racism operates by making non-western culture too concrete, and thus "closer to nature" – not really a culture at all, but rather beings of uncontrolled emotion and direct bodily sensation, rooted in an edenic ecology. Orientalist racism operates by making non-western culture too abstract, and thus "arabesque" – not really a "natural" human, but one devoid of emotion, caring only for money and an inscrutable spiritual transcendence. Racism on the African continent – tending towards Orientalism in the north, and Primitivism in the south – precludes any simple opposition that a category like "African cybernetics" might hold. An anti-racist characterization of African influences in cybernetics must be situated in ways which do not merely reverse or refute its claims, but address its historical construction. Opposition to racism has often been composed through two totalizing, essentialist strategies: sameness and difference. For example, Mudimbe (1988) demonstrates how the category of a singular "African philosophy" has been primarily an invention of difference, having its creation in the play between "the beautiful myths of the 'savage mind' and the African ideological strategies of otherness." In contrast, structuralists such as Levi-Strauss have attempted to prove that African conceptual systems are fundamentally the same as those of Europeans (both having their basis in arbitrary symbol systems). The problem of these unitary assessments of epistemological status is made particularly clear by the contradictions in the philosophic approach of Sandra Harding, where African conceptual views were at first characterized as he holistic opposite of Western reductionism (Harding 1989), and then soon after as having exactly he same analytic approach as Western science (Harding 1990). As Mudimbe notes, neither sameness nor difference will suffice.

This critique indicates that the analysis of interactions between cybernetic theory and the African diaspora should not be limited to a purely epistemological perspective. At the same time, however, socially grounded analyses of science have all too often presented a kind of "Realpolitik" approach to the social construction of cybernetics, one in which the science of computation and control systems is merely a thin disguise for methods of social domination and control (e.g., Lilientfeld 1974). Here any subaltern identity (female, non-white, working class, etc.) appears only as yet another powerless victim, and typically one for whom a previously natural existence is endangered by the intrusion of artifice. Thus the focus of this essay on African contributions to cybernetics is not an attempt to overlook the brutal tragedies enacted by that science, but rather to underscore the multifaceted aspects of its history, and thus possibilities for resistance and reconfigurations. By moving between questions of epistemological structure and social constructions of science, this essay will suggest some possible origins of cybernetic theory in African culture, ways that Black people have negotiated the rise of cybernetic technology in the West, and he confluence at these histories in the lived experience of the African diaspora.

Information and Representation in Cybernetics

Cybernetic theory is based on two dimensions of communication systems. One is the information structure, the other the physical representation of that information. The most fundamental characteristic of an information structure is its computational complexity, which is a measure of its capacity for recursion (i.e., self-reference, reflexivity). This mathematical result agrees nicely with our intuition about the crucial role of reflexive awareness in our own "information structure." The most fundamental characteristic of a representational system is the analog-digital distinction. Digital representation requires a code table (the dictionary, Morse code, the genetic code, etc.) based on physically arbitrary symbols (text, numbers, flag colors, etc.). Saussure
postulated this characteristic when he spoke of the "arbitrariness of the linguistic signifier." Analog representation is based on a proportionality between physical changes in a signal and changes in the information it represents (e.g., waveforms, images, vocal intonation). For example, as my excitement increases, so does the loudness of my voice. While digital systems use grammars, syntax, and other relations of symbolic logic, analog systems are based on physical dynamics – the realm of feedback, hysteresis, and resonance. This dichotomy is fundamental to current cybernetic debates concerning, for example, which type of representation is used by neurons in the human brain, or the type recommended for artificial brains.

In the first years of American cybernetics, analog and digital systems were seen as epistemologically equivalent, both considered capable of complex kinds of representation (cf. Rubinoff 1953). But by the early 1960s a political dualism was coupled to this representation dichotomy. The "counterculture" radicals of the cybernetics community – Norbert Wiener, Gregory Bateson, Hazel Henderson, Paul Goodman, Kenneth Boulding, Barry Commoner, Margaret Mead, among others – made the erroneous claim that analog systems were more concrete, more "real" or "natural," and therefore (according to this romantic cybernetics) ethically superior. In social domains, this converged with Rousseau's legacy of the moral superiority of oral over literate cultures (1). Thus, for example, McLuhan (1966) writes:

> It was a considerable revelation when writing came to detribalize and to individualize man. Cybernation seems to be taking us out of the visual world of classified data back into the tribal world of integral patterns and corporate awareness (McLuhan 1966, p 102).

For African-Americans this meant a debilitating valorization. They could use this ethical claim to combat some racism, but only in terms of identifying as unconscious, innocent natives in a lost past. Thus African modes of representation in the use of sculpture, movement and rhythm were often abandoned to modernist claims that Africa was the culture of non-representation, the culture of the Real. By the 1970s, widespread epistemological critiques of realism – noting that it is representation that allows self-consciousness and intentionality – resulted in interpretations which limited cultural analysis to arbitrary signifiers. African dance, for example, would be a set of movement symbols, not a waveform.

Subsequently, African cultural analysis became split between those who retained the modernist trope of African identity grounded in naturalist realism (recognizing analog systems but refusing to see them as representation), versus those who adopted to postmodern trope of textual metaphor (which avoids primitivism at the expense of abandoning recognition of analog systems) – reggae versus rap (2).

Postmodern cybernetics, however, has shown that analog systems are capable of the flexible representation required to perform complex (Turing Machine-equivalent) computations, as demonstrated in both theory and experiment (Wolfram 1984, Touretzky 1986, Rubel 1989, Blum, Shub and Smale 1989). In particular, a new appreciation for analog systems was fundamental to the rise of fractal geometry, nonlinear dynamics, and other branches of chaos theory (Gleick 1987, see also Dewdney 1985, Pagels 1988). By viewing physical systems as forms of computation, rather than merely inert structures, researchers became open to the possibility of having infinite variation in deterministic physical dynamics. Analog systems can achieve the same levels of recursive computations as digital systems; the two are epistemological equals.

In other words, the appeal to digital systems in African culture may well have been a necessary antidote to the skewed social portrait of it, but it is not the only recourse for combating ethnocentric epistemological claims. African cultures pave indeed developed systems of analog representation which are capable of the complexities of recursion, and there are indications that this indigenous technology has been in conversation with cybernetic concepts in the west.

Africa in the origins of the cybernetics

The use of African material culture as a form of analog representation is particularly vivid in cases of recursive information flow. In African architecture, recursive scaling – that is fractal geometry – can be seen in a variety of forms. In North Africa it is associated with the feedback of the "arabesque" artistic form, particularly in the branches of branches forming city streets. In Central Africa it can be seen in additive rectangular wall formations, and in West Africa we see circular swirls of circular houses and granaries. This is not limited to a visual argument; the fractal structure of African settlement patterns has been confirmed by computational analysis of digitized photos in Eglash and Broadwell (1989).
Recursive scaling in Egyptian temples can be viewed as a formalized version of the fractal architecture found elsewhere in Africa, and is most significant in its use of the Fibonacci sequence (Badawy 1965; see Petruso 1985 for additional Egyptian use of the sequence). The sequence is named for Leonardo Fibonacci (ca. 1175-1250), who is also associated with an unusual example of recursive architecture in Europe (Schroeder 1991, p 85). The Fibonacci sequence was one of the first mathematical models for biological growth patterns, and inspired Alan Turing and other important figures in the history of computational morphogenesis. Since Fibonacci was sent to North Africa as a boy and devoted his years there to mathematics education (Gies and Gies 1969), it is possible that its seminal example of recursive scaling is of African origin.

Benoit Mandelbrot, the “father of fractal geometry,” reports that his invention is the result of combining the abstract mathematics of Georg Cantor with the empirical studies of H. E. Hurst. Cantor was a nineteenth-century Rosicrucian mystic, who often combined his mathematics with his religious belief. His cousin Moritz Cantor was a famous scholar in the geometry of Egyptian art and architecture. Given these facts, and the similarity of this first European fractal to the Egyptian architectural structure symbolizing creation (the lotus), an Egyptian origin is likely here as well. H.E. Hunt also has Egyptian connections, as will be discussed shortly.

Goldsmith (1981) reports golem legends going back to the fourth century B.C.E., and describes their continuing popularity in Jewish legend. Norbert Weiner the Jewish dean of analog cybernetics was quite influenced by this concept of information embedded in physical dynamics (Heims 1984, Eglash 1992). He made several references to the golem in his writing, and reported that even as a child he was fascinated by the idea of making a doll come alive. His religious identity was closely tied to gashmuit, the informal, physical (and traditionally female) side of Judaism, and he was particularly proud of his ancestry to famed Egyptian physician Moses Maimonides.

In addition to spatial analog representation many African societies have developed techniques for the analog representation of time-varying systems, including transformation into frequency or phase-domain representation. We see animist energy flow, drawn by a Bambara seer for the author, visualized as a sort wave emanating from a sacrificial egg. The dashed lines inside the figure are a digital code symbolizing good fortune. Undulatory schemes in Egyptian art (Badawy 1959) show an understanding of motion as a rhythmic time series, and the transformation of time-series to a frequency-domain representation can be seen in African conceptualizations of circular time. The extreme in African time-series analysis is he search for patterns in the Nile floods. The most recent data set, taken once a year for 15 centuries, became the basis for the work of H.E. Hunt mentioned previously. A British civil servant, Hurst spent 62 years in Egypt, and finally deduced a scaling law, based on this time-series, which Mandelbrot used to bring Cantor's abstract set theory into empirical practice.

The most common frequency analysis used by Weiner and others in modern cybernetics is the Fourier transform. Fourier began his work with an analysis of Descartes' equations; he did not leave this static framework until his expedition to Egypt in 1798, where he analyzed the geometry of Egyptian architecture. It was here that he devised the basis for the Fourier transform. A comparison of Fourier's visualizations of convergence of a sequence with a diagram of Egyptian architecture (which, because of the Fibonacci sequence, also shows convergence to a limit), suggests that the African concept of recursive structure and dynamic form may have contributed to this analysis as well.

African influence in American cybernetics

Related to these systems of analog recursion are studies on computational self-reference; these too have possible African influences For example, Seymour Papert, a white computer scientist who championed hierarchical non-recursive computing in the 1960s, made a dramatic conversion to tralized computation following his U.N. work in Africa in the mid-70s. Another white engineer, N. Negroponte, developed his conceptions for self-organized computing following his study of "vernacular architecture," most of which was African. Earl Jones, one of the first African-American computer engineers, was in innovator in decentralized data distribution.

Analog computing networks have become increasingly important in the post-modern phase of American cybernetics, where they are no longer a stronghold of holistic hippy science, but rather a promising (and well-funded) area of research for the military and industry (Eglash 1990, 1992). African influences in American cybernetics - Ron Eglash
http://www.haussite.net/haus.0/SCRIPT/txt2001/01/eglash_X...
science date back to the contributions in biological knowledge and metalwork by slaves; the biological (especially botanical) is particularly significant for cybernetics due to its involvement in models of information coding. While romantic accounts of cultural difference would use botanical expertise to emphasize the "naturalness" of African traditions, this is certainly not the only interpretation. George Washington Carver, for example, declared that not only did God create the Kingdom of Plants and the Kingdom of Animals, but that he also had a "Kingdom of the Synthetic." This spiritual legitimation of artificial fits well into the African traditions of analog representation discussed previously.

A direct line for African influences in analog cybernetics can be seen in the work of E. E. Just, who used music as both a conceptual model for decentralized biological morphogenesis, and as a cultural basis for understanding his African heritage (Manning 1983, pp. 203, 261). Just's work, particularly that on information encoded in non-symbolic representation (based in part on Just's rebellion against the position that the only intracellular information is that of a "master code" in the cell nucleus), was taken up by Ross G. Henderson, an important influence in the General Systems Theory (GST) community (Haraway 1976), which in turn influenced the origins of cybernetics through studies of aggregate self-organizing phenomena and positive feedback loops.

As previously noted, the GST and related cybernetics community took a romanticist turn in the 1960s, which resulted in a disabling of the analog conception by Realism (cf. Varela's account of the "normpresentationist point of view" developed in the 1960s with McCulloch, Maturana, and others(Varecia 1987, pp. 48-491)). What little involvement the Black community had in the cybernetics movement was, however, often opposed to this romantic tendency. For example, at the first Cybercultural Research conference in 1966, James Boggs, a Black political activist, suggested that the "new cybercultural society" would not be alienating to Blacks because (unlike whites) they could draw on a labor history in which their dual identity as both biological automatic machines and the makers/users of machines were deeply imbricated with their cultural identity (Boggs 1966, p. 172). Black identification with categories of the artificial are here political, but converge with the same conceptions that informed Carver and others; concepts that parallel he animist legitimations of the artificial in Africa.

The lived experience of African-Americans' interactions between these African diasporic innovations and their survival of American racism is particularly apparent in me work of African-American women. As Nakano Glenn (1992) argues for the case of service workers, gender and race cannot be reduced to "additive oppressions," and must be seen as the site of an interlocking or relational dynamic. For example, bob the traditional work of African women (Hay and Sticher 1984) and specific labor locations for women of an ethnicities in America have contributed to the frequency of their involvement in biomedically related fields. From 1876 to 1969, over half of the Black women science Ph. D.s have been in bio-sciences (Jay 1971), and the Black women inventor, Clara Fry, specialized in health-care tools (James 1989, p. 80). The most relevant example in cybernetics is the work of Patricia Cowings, who makes cyborgs for NASA. In an interview in this volume, Cowings discusses her use of analog biofeedback as a method for reducing motion sickness in space, and notes several complex interactions between her identity as a Black woman and her successful career in cybernetics. Yet she has distanced herself from any simple mimesis of "African culture" in her construction of cybernetics. The contributions of African-American women to what has become modern cybernetics should be seen as a form of resistance that cannot be reduced to either the restoration of tradition or a relocation to universalism.

Black cybernetics in the postmodern era

The rejection of cybernetic romanticism by radical African-Americans was no longer necessary by the mid-70s, when youth sub-culture had turned from hippy naturalism to the urban affinity of punk-rock and hip-hop (Hall 1980, Hebdige 1987, hooks 1990). Thus the popular rap group Digital Underground displays an appreciation of cybernetics which is politically oppositional but no longer primitivist or naturalizing. While the impact of new cybernetic technologies on African-American communities has been part of a long history of labor displacement (Jones 1985, Hacker 1979), environmental racism, and other subjugations, here we can also see some hints for the appropriation of technology in new configurations. For example, the famous "scratch" sound in hip-hop came about when the normally silent back-cue of the dee-jay's turntable was amplified and moved in time to the beat, thus changing a passive reproduction into an active synthetic instrument; turning tables on the turntable.

To what extent is this subcultural cybernetics merely "bricolage" -- reassembling available components for a
practical goal — and what extent is it a deeper understanding of abstract principles? First, we should note that "official" cybernetics is both; it used pre-existing abstract principles — feedback, information theory, etc. — for practical application in a new assemblage. Indeed, the divisions between bricolage and science in general are far more permeable than we had been led to believe. This point has been admirably made in Sherry Turkle's study of bricolage programming styles in the hacker community, where she also notes that the interaction between popular culture and the scientific community is an active source of ideas in both directions.

Let us pursue this question a bit further. Setting aside both the definition of cybernetic and its interaction with popular culture, what kinds of technological capability does the vernacular cybernetics of the African-American community represent? One clear illustration can be fond in the striking utilization of the analog/digital dualism for the production of musical signifiers in the divisions between reggae and rap music. As previously noted reggae is more aligned with he naturalizing trope modernity, and rap with the artificial affinities of the postmodern. In reggae we see the language of analog representation. "Rastaman Vibration" lets us "tune into de riddim;" we become resonant nodes linked by the waveforms of a polyphonic beat. In rap music it is digital communication that signifies cultural identity. Natural harmonies are broken up by arbitrary soundbites and vocal collage, and the melody is subordinated to a newly spliced code; a mutant reprogramming of the social software.

From the viewpoint of cultural studies, the utilization of the analog/digital division in reggae vs. rap does indeed count as a technological capability. But would it also count from the view of a cybernetics engineer? The use of the scratch sound mentioned cadet is associated with the birth of Rap, but phonograph records are analog devices. Similarly, reggae makes use of an army of both analog and digital audio equipment. Isn't the use of technological language by African diasporic subcultures merely linguistic play? The answer is no. Despite (in fact because of) the wide assortment of apparatus, rap and reggae artists have created a technology for signal processing that would indeed meet the specificities of current cybernetics engineering. The evidence for this begins in the work of Richard Voss, who first measured the fractal dimension for various types of acoustic communication in 1977. Voss discovered that the physical arbitrariness of digital signifiers meant that the waveforms of digital communication were a succession of fairly random signals, overall creating a "white-noise spectrum." In analog waveforms, on he other hand, long-term changes in information were reflected in long-term signal changes. Since there were similar information changes on many scales, the result was a fractal structure, a "1/F noise spectrum," in the case of analog communication. Thus the waveform created by pitch changes in speech, which are primarily due to the phonetic differences between words, tends toward a white-noise spectrum, while the pitch signal of music shows the fractal structure of analog representation.

Voss (1988) later showed that this relationship held for all types of music, both instrumental and vocal, with samples ranging from Indian ragas to Russian folksongs. My own studies (Eglash 1993) show that while reggae music also has this fractal structure, rap is the only music (aside from avant-garde experiments such as those of John Cage) which violates this rule. The reason for his is the intentional violation of analog representation by digital coding, a violation that invokes rap artists' oppositional stance, but also offers a positive outlookin the possibilities for their cybernetic innovation. Moreover, the rap-reggae fusions that are now becoming increasingly popular (e.g. ragamuffin) have characteristics which indicate that their signals are likely to avenge a fractal dimension value half-way between the two. This precision of control over an abstract cybernetic principle indicates that it is not simply a matter of the adaption of terminology; African diasporic identity is expressed in these examples through a conscious manipulation of complex signal characteristics.

Applications to science education

One might think that such rich vernacular cybernetics would be an obvious resource for improving science education, but such opportunities have been ignored. For example, The National Assessment of Educational Progress reported in Anderson (1989) suggests that Black high-school students have cultural barriers to their participation in science, based on studies which supposedly indicate "fewer science-related experiences" (p. 45). But the examples of such experiences — planting a seed, watching an egg hatch — are primarily naturalistic; the artificial realms of video games and audio technology, which are surely "science-related," are completely excluded. Even more disturbing is the claim of "cultural barriers" based on reports that "a substantial portion of Blacks did not have confidence in the ability of science to solve most or some of our problems" and that they were "less convinced of the benefits of science to society." Here a potential route to involving Black youth in science education — by recognizing their critique as an intelligent understanding of
science history – is instead dismissed as ignorance.

Similarly, an ideology of individualism is persistently portrayed as a neutral, universal characteristic of scientific style and rational thought (e.g., Pearson 1985, p. 174) which African-Americans must adopt. But like the turn to collective computation in cybernetics, collective scientific production can often be a robust path to success. Both this obligatory individualism, and the previously noted naturalistic assumptions, operate the NAEP's report that African-American youth "did not believe so strongly as their national peers that individuals' actions can make a difference in solving societal problems." Reluctance toward "using an economy can separating trash for recycling, or turning off lights" are symptoms of this pathology (p. 48). A better understanding of African-American cultural connections to science would suggest that such individualistic approaches are neither universal nor uniquely beneficial.

Conclusion

In summary: the history of African interactions with cybernetics does not revolve around a single essence. It includes white engineers bringing ideas from Africa and Black engineers who make no claims about inspiration from any ethnic tradition. A portrait of the multivariate dynamics between the African diaspora and the information sciences – from the celebration of popular culture to the struggle of minority scientists – must be brought together with an understanding of the lived experience of people, from a multiplicity of ethnic configurations, who have found themselves fused, networked and oddly interfaced in the evolution of cyborg society.

(footnotes)