Discussion and Criticism[1]

On Human Fertility: Individual or Group Benefit?

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Caldwell et al. (CA 28:25–43) have pointed to the pervasive influence of Carr-Saunders's (1922) concept of population regulation throughout two-thirds of a century of anthropology and demography. Carr-Saunders developed the notion that members of "premodern" populations depress their fertility to maintain the "optimum number" for group welfare because ethnographies showed that hunter-gatherers were not pushed by Malthusian forces to lead miserable lives of endless toil. The influence of this notion of the "optimum number" was magnified by the work of Wynne-Edwards (1962), who (citing Carr-Saunders) elaborated it to apply to animals in general. Wynne-Edwards argued that aspects of social behavior from male display and dominance hierarchies to territoriality were mechanisms to control population growth and prevent resource depletion. Cultural ecologists in turn built theories of human social systems regulated by practices to limit population growth and deploy groups in time and space for the efficient use of their resources, often referring to Wynne-Edwards for biological foundation. Warfare (Rappaport 1967, Vayda 1971), male supremacy and female infanticide (Harris 1977), the origins of agriculture (Flannery 1973, Cohen 1977, Harris 1977) and its intensification (Boserup 1965, Harris 1977), patterns of social inequality and the origins of the state (Harris 1977), forms of religious belief and practice (Harris 1977), and the industrial revolution (Harris 1977) were explained as means (of varying effectiveness) that social systems use to promote group welfare by reducing population pressure (Hammel and Howell, CA 28:141–60). Informed by anthropological generalizations, demographers viewed recent high rates of population growth in the Third World as the legacy of colonial interruptions of traditional practices which were assumed to have maintained "optimum numbers" in the precolonial past (Caldwell et al., CA 28:25–43).

While anthropologists and demographers adopted the view that hunter-gatherers (and other traditional peoples) past and present usually practice the discipline of "optimum numbers," this notion of population regulation suffered a very different fate in biology. Wynne-Edwards's 1962 extension of Carr-Saunders's hypothesis was a major stimulus to behavioral ecology because of its central *flaw*. His coherent argument and detailed examples made it clear that individual reproductive interests and long-term group or population homeostasis would not always favor the same patterns of behavior. Williams (1966) criticized the expectation that population- or species-level consequences could ever be the goals of natural selection. This revolutionized the study of animal behavior. Williams later collected the key thoughts of Wynne-Edwards, W. D. Hamilton, J. Maynard Smith, David Lack, and others in a special volume devoted to the topic of individual- versus group-level benefit (1971). Recently Wynne-Edwards has renewed his hypothesis that populations evolve mechanisms to regulate their numbers so as not to overexploit their food resources (1986; see Charnov 1986 for review). Yet, modern behavioral ecology is testimony to the remarkable fruitfulness of the contrasting hypothesis that natural selection favors traits that increase individual reproductive success, *independent of population-level effects* (Maynard Smith 1982, Krebs and Davies 1987, Daly and Wilson 1983, Trivers 1985, Charnov 1982). Even though the theoretical possibility of group-level benefits (particularly with kin groups) cannot be denied (Wade 1978, Wilson 1983), general reproductive restraint to conserve group resources is most unlikely for any population (Charnov 1986). It has been by focusing attention on conflicts of reproductive interest between individuals that modern behavioral ecologists have made such progress in understanding social behavior (Maynard Smith 1982, Krebs and Davies 1987, Trivers 1985, Charnov 1982).

Behavioral ecologists have come to view responses to declining resources as adjustments that generally *increase* rather than lower the lifetime reproductive success individuals can achieve under deteriorating conditions. Individuals by delaying reproduction or producing fewer offspring in a resource-poor season often *increase* the number of descendants who survive to be reproductively successful themselves. Rather than lowering rates of population growth, these adjustments make rates *higher* than they would otherwise be as resources decline. This perspective, however, has had little impact on anthropology and demography. The notion of "optimum numbers" and various other models of group- or society-level functions have met occasional criticism on grounds of theoretical inadequacy in the social sciences (Hardin 1968, Alexander 1979, Chagnon and Irons 1979), but the effect of these objections has been limited. It is of

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special interest that the Caldwells, ignoring events in biology, mount their criticisms not from theory but from facts. They note how few and precarious are the empirical data anthropologists and demographers repeatedly echo to support the notion of the "optimum number" and its corollary of "primitive affluence" (Sahlins 1972), whereby hunter-gatherers, stepping lightly on their resources, meet their modest needs with little effort. Caldwell et al. review the profound influence of these hypotheses and call for more careful quantitative work to test them.

Some of this quantitative work has already been done. The ethnographic case most widely cited (e.g., Harris 1977, Cohen 1977, Sahlins 1972) to illustrate both maintenance of the "optimum number" and "primitive affluence" among hunter-gatherers is that of the !Kung of Botswana. The exceptional research of Richard Lee and Nancy Howell provides data used to show low work effort, resource abundance, and low fertility, primarily due to interbirth intervals that are usually four years long (Lee 1968, Howell 1979). Nearly ten years ago, intrigued by the data and argument, Blurton Jones and Sibly (1978) wondered whether !Kung mothers were actually working as hard as they could to have as many surviving children as possible, in spite of appearances to the contrary. They approached the problem as biologists and were skeptical that individual members of a population would hold down their reproduction to maintain an optimum group number. They considered the ecological constraints on !Kung mothers described by Lee (1972) and modeled the consequences of varying interbirth intervals for mothers' work loads. Their 1978 paper showed that, given local conditions, the interbirth interval likely to give the *most* surviving children was four years. Subsequently, Blurton Jones (1986, 1987) used the reproductive histories of !Kung women collected by Nancy Howell to show that the actual spacing of births is remarkably close to the pattern which *maximizes* the number of children that survive to be teenagers.

Blurton Jones's work has gone largely unnoticed in the social sciences (for example, it is cited neither by the Caldwells, whose coverage of anthropological demography is otherwise remarkably broad, nor by Hammel and Howell in their discussion of ways in which human populations respond to population pressure. This may be partly because theories of group-level functions have been fundamental to the development of anthropology. If the hypotheses of "optimum number" and "primitive affluence" do come under the more general suspicion that is warranted on both theoretical and empirical grounds (e.g., Blurton Jones and Sibly 1978; Blurton Jones 1986, 1987; Bates and Lees 1979; Hawkes and O'Connell 1981; Smith 1984; Hill et al. 1985; Hawkes et al. 1985; Hawkes 1987), the changes in anthropology and demography will likely be profound.

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On Klein's "Analogy and Mysticism and the Structure of Culture"

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Klein (CA 24:151–80) proposes a mathematical operator for the calculation of complex analogies, the "appositional transformation operator" (ATO), that could provide a powerful tool for symbolic analysis. He illustrates the operator through application to the *I Ching* and asserts that it is found throughout the cultures of humankind. I will evaluate the ATO model (and his claims for it) from two points of view: (1) mathematical precision and consistency and (2) applicability to cultural symbolic systems. These two aspects are particularly relevant to my research, which uses mathematical definitions of analogy to model symbolic systems evidenced in rituals of traditional cultures. Klein's work is important in this regard because he claims to offer a mathematical definition of analogy sufficiently general to apply to any analogical cultural symbolic system.

Klein's mathematical system contains an ingenious innovation, but it is presented with an imprecision that has allowed for inconsistent application. Though he finds an ideal application in the *I Ching,* serious problems arise when he attempts to apply it to cultural symbolic systems in general. Further, the ATO system contains stronger conditions than are warranted for a general model of analogy. Another problem of applicability arises from Klein's unsubstantiated claim that cultural rules are encoded in surrealistic images through ATOs. If this claim were true, it would be an earthshaking development for symbolic anthropology. Unfortunately, it is not.

COMPETING MATHEMATICAL MODELS

Klein argues that his "appositional transformation operator" represents an advance over propositional models in its economy in calculating complex analogies. He does not specify the competing models, so we can only speculate what he has in mind. For instance, he does not refer to Lorrain (e.g., 1974) or Hesse (e.g., 1960), who have suggested formal definitions of analogy. He cites only a brief piece by Morrison and Durrenburger (1976) that does not contain their definition of analogy (see Durrenburger and Morrison 1977). This is surprising, since he seems to share their interest in brain processes. Moreover, he ignores their major point that many analogies that are considered formally consistent with most definitions of analogy should not be acceptable, thus raising doubts about the definitions. And, as Harnad points out in his comment (pp. 170–71), Sternberg (e.g., 1977) and Anderson (e.g., 1981) share with Klein an interest in artificial intelligence as well as analogy but go unmentioned.

A model formally equivalent to Klein's has been suggested by Hage and Harary (1983*a*:151–57; 1983*b*) in works that appeared nearly simultaneously with his, and a less general version of the model was used earlier by Hage (1979) in an article that Klein might have benefited from consulting. In contrast to Klein, Hage and Harary do not refer to their model as analogical; they call it "Boolean groups." Both models are offered as formalizations of Lévi-Strauss's myth analyses, which deal with transformations among sets of pairs of contrasts. Whereas Hage's earlier article is restricted to the system formed by two pairs of contrasts, Klein's approach allows for any number of pairs of contrasts (as does Hage and Harary's model). All these models are known to algebraists as external direct products of the binary permutation group (Herstein 1975:103–4).

Klein's model is more easily applied than Hage and Harary's because of his ingenious binary notation, which allows the computation of permutation products by manipulating strings of binary digits rather than consulting a table of composition of permutations. However, Klein's presentation ignores global properties of the systems noted by Hage (1979:85) such as closure and associativity (see appendix). With Klein, Hage and Harary (1983*a*:166–70) recognize the *I Ching* as an example of their model, but they do not develop the example in the same detail.

ATOS AND ANALOGY

"Appositional transformation operators" relate situation descriptions in the form of feature arrays (n-tuples or matrices of binary digits). (An n-tuple is an ordered string of digits n digits long.) The n-tuples describe the presence or absence of features with binary digits: 0 and 1. For example, the concept of "woman" might be described with reference to the features of "adult" and "male." Using "1" to indicate the presence of the feature "adult" and "0" to indicate the absence of the feature "male," we can describe the concept of "woman" with the 2-tuple (1,0). This description requires an agreement about the order of the features' occurrence in the 2-tuple. In this case we have chosen to put information concerning "adult" in the first place and information concerning "male" in the second. Klein has devised a means of com-