

# **The Natural History of Human Food Sharing and Cooperation: A Review and a New Multi-Individual Approach to the Negotiation of Norms**

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## Introduction

Humans share food unlike any other organism. Many other animals, including eusocial insects (bees, ants, termites), social carnivores (lions, wolves, wild dogs), some species of birds (e.g. ravens) and bats (vampire), actively share food; however, the patterning and complexity of food sharing among humans is truly unique. Unlike other mammals, for which food sharing between mothers and offspring is limited largely to lactation during infancy<sup>1</sup>, human parents provision their children until adulthood. Moreover, the sharing of food between human parents and their children continues bi-directionally until death in most traditional non-market societies. Additionally, marriage is universal among human societies, and husbands and wives regularly share food with one another throughout their marriage. Food sharing within human families is based upon a division of labor in subsistence effort by age and sex, where tasks are divided and the proceeds of work are shared. In fact, within-family transfers of food are so universal among humans, that they are largely taken for granted and have rarely been systematically studied. This gap is ironic since the sexual division of labor and the concomitant sharing of food between spouses and between parents and offspring, have figured prominently in several models of hominid evolution (e.g., Isaac 1978; Lancaster and Lancaster 1983).

In addition to within-family food transfers, food sharing sometimes extends beyond the nuclear family in many societies; indeed, sharing is rather pervasive in numerous foraging societies. Most recent research on food sharing has focused on food transfers among adults living in different households. The majority of this research has been conducted in small-scale societies, particularly hunter-gatherers and groups that combine simple horticulture with hunting and gathering (forager-horticulturalists). There are two reasons for this focus. First, inter-familial food sharing is pervasive among hunter-gatherers and many forager-horticulturalists; they are often referred to as egalitarian societies. Second, hominids lived as hunter-gatherers for the vast majority of their evolutionary history (over 2 million years). Agriculture originated only about 10,000 years ago and has been practiced by the majority of the world's population for only two or three millennia. Since most hunter-gatherers share food on a daily basis, studies of food transfers among foragers may provide important insights into the evolutionary basis of human food sharing and more generally, about the origins of human hyper-sociality.

This paper has three principal objectives. The first is to provide a brief review of existing theory and research about food sharing in small-scale societies for non-specialists. In the first part of the paper, we outline the principal hypotheses proposed to account for variation in food sharing and evaluate available evidence pertaining to those hypotheses. The second objective

is to present evidence regarding why we consider it necessary to re-think existing approaches to food sharing. In this second part of the paper, we argue that intra-familial resource flows are critical to the understanding of inter-familial sharing and that neither the human life course nor human intelligence could have evolved without long-term imbalances in flows of food between families. We suggest that future enterprises should consider small group decision processes and the emergence of institutionalized sharing norms. In the third part of the paper, we review several case studies of food sharing in different societies and across contexts within societies as a preliminary step towards building a theory of how those norms may respond to local ecological conditions. The paper concludes with a discussion of new directions for research and some major unresolved questions that should be addressed.

## **Part I: Theory and empirical evidence**

Six different theories have been proposed to explain the existence and patterning of intra-group food sharing.

### *I. Reciprocal altruism*

Several investigators have proposed that reciprocal altruism (Trivers 1971), where food at one point in time is exchanged for food at some later time, may explain many or most cases of human food sharing (Kaplan and Hill 1985; Winterhalder 1986; Smith 1988). The pervasiveness of reciprocal food sharing among humans is commonly explained in terms of the kinds of foods they exploit and their inherently “risky” nature (ibid). Human hunter-gatherers tend to specialize on the largest, highest-quality, most nutrient-dense foods available in their environments (Kaplan et al. 2000), and as a result, they experience high variance in foraging luck due to the difficulty in acquiring these items. For example, individual Ache hunters return empty-handed on 40% of all days they hunt, but some days return with several hundred thousand calories of meat (Hill and Hawkes 1983). Hunting success is even more sporadic among large-game hunters, such as the Hadza, who only acquire meat on about 3% of hunting days (Hawkes et al. 1991). Since there are diminishing returns to consumption of large quantities of food, especially in environments where spoilage is a problem, and because food portions are very valuable to hungry individuals, reciprocal sharing can significantly reduce variation in day-to-day consumption and maximize the inter-temporal utility of food. Reciprocal altruism therefore allows people to devote time and energy to the pursuit of large, asynchronously acquired, high-quality packages. Trade is a special form of reciprocal altruism where the return benefits of giving are in another currency, such as meat for sex, food for labor,

or fish for yams. However, when the return benefit is a non-food currency, such as increased mate access, such sharing does not serve the goal of risk-reduction.

## II. *Cooperative acquisition and byproduct mutualism*

The acquisition of difficult-to-acquire foods, especially wild game, often requires the coordinated efforts of several individuals. However, usually only a single individual is identified as the owner of the acquired resource, determined by cultural-specific norms of ownership (e.g. hunter who makes first lethal shot, finder, killer – Dowling 1968). In many groups, sharing among task group members occurs as an initial wave of sharing (e.g. Pygmies – Bailey 1991; Harako 1976). Owners may reward non-owners for their current cooperation by giving them shares of the resource, but this sharing may also act as a means of insuring future cooperation in similar food production activities. Thus, sharing is a form of trade-based reciprocal altruism, where labor is rewarded with food. An alternative interpretation of the same phenomenon is that engaging in group production when there is sharing provides participants with higher per capita returns than if they produced food by themselves. Thus, group production may represent a form of byproduct mutualism (Clements and Stephens 1997; Dugatkin 1997; Alvard and Nolin in press). Once rigid sharing norms exist in a population, the decision to participate in, say, a group whale hunt or cooperative monkey hunt should depend only on the higher per capita return rates relative to those that could be gained in solitary subsistence activities (see Alvard 2001). Thus, an advantage of strong sharing norms is that they act to transform the payoff structure of group food production strategies from that of a Prisoner's Dilemma to that of a mutualism.

## III. *Tolerated theft or scrounging*

Building on the same insights regarding large, asynchronously acquired food packages and diminishing returns to consumption of large food quantities, others have proposed that much apparent pro-active sharing may actually be “theft” or scrounging of food from acquirers by individuals who have little or none (Blurton Jones 1984; 1987). This hypothesis is based upon the assumption that asymmetries between individuals in the marginal value of additional food can lead to contests over packages. The hungry person is more motivated to fight, while the person with more should relinquish some food because the lost food value is not worth the fight (Blurton Jones 1987; Winterhalder 1996). When power or ‘resource holding potential’ is equal among contestants, a simple prediction of tolerated scrounging is that distributions will be highly egalitarian, such that any additional food portions have the same marginal value for each

contestant (Winterhalder 1996).

Proponents of this view have pointed out that tolerated theft in the context of large, highly variable foods raises a secondary problem. Why do people spend time foraging for large packages if they know that much of what they acquire will be scrounged from them? Scrounging of large packages may effectively reduce their per capita consumption return rate below several other food production options in the environment, especially the pursuit of small packages (Hawkes 1993). To answer this question, Hawkes (1991; 1992; 1993) proposed that the pursuit of large packages, particularly hunted foods, is very sex-biased and that men acquire large packages to 'show off' and garner attention. Men focus their efforts on acquiring large packages, precisely because they will be scrounged from and as a result, gain the attention and support of scroungers, many of whom will be women. The payoffs to this attention presumably come in the form of increased access to women and increased numbers of offspring.

#### *IV. Costly signaling*

Costly signaling is an extension of the show-off hypothesis that may explain why certain individuals (usually men) pursue difficult-to-acquire foods that often yield sub-optimal caloric return rates (Smith and Bliege Bird 2000; Gurven et al. 2000b; Bird and Smith 2001). The costliness of the signal insures the honesty of the information being advertised (Zahavi and Zahavi 1997; Grafen 1990; Johnstone 1997). The signal might provide information about phenotypic quality (such as disease-resistance) or about intentions to cooperate in the future. Recipients of the signal confer benefits on the generous donor not as payback for food given, but because information about the donor's phenotypic quality makes that donor a desirable partner, mate, or ally. Costly signaling differs from showing-off because it does not rely on tolerated theft to explain food transfers. Additionally, because the honesty of the signal makes the signaler an attractive partner, costly signaling avoids the second order-collective action problem of who should payback prestige to good hunters.

#### *V. Nepotism based on kin selection*

Because biologically related individuals share a non-random percentage of one's genes by descent, any behavior that sufficiently benefits kin can be favored by natural selection. According to models developed by Hamilton (1964), natural selection will favor altruism to kin when the benefits to the recipient, discounted by Wright's coefficient of genetic relatedness between donor and recipient, outweigh the costs of giving. A simple prediction is that, all else being equal, close kin should receive shares either more frequently or in greater quantities than

distantly related and unrelated individuals (Feinman 1979). It has also been argued that among close kin, we should expect to find greater imbalances in quantities given and received among close kin than among non-kin or distant kin (Hames 1987; Feinman 1979). However, this might not be true if close kin are also reciprocity partners and if reciprocal altruism is an important factor influencing food transfers among kin (Gurven et al. 2000a).

#### VI. *Trait-group selection*

Selection among groups has also been proposed in order to explain cooperation and food sharing within human groups (Wilson 1998; Boyd and Richerson 2001; Boehm 1993). In group selection models, the relative fitness of altruists is lower than that of selfish individuals within groups, but the average fitness of individuals in groups containing more altruistic members is greater than those in groups containing fewer altruists. Group selection could favor costly food sharing if the increased absolute fitness of altruists within groups in a meta-population outweighs the decrease in relative fitness within groups, where “group” refers to any congregation of individuals (Wilson 1990; 1998). While the conditions favoring trait-group selection are much less stringent than those of older group selection models, its overall influence is still limited by grouping patterns and migration, and ultimately may be no more revealing than egoistic models (Harpending 1998; Krebs 1987). However, given the conflict between group and individual interests, cultural means of encouraging individuals to share food may increase the frequency of giving within groups (Simon 1990; Boyd and Richerson 2001), leading to socially enforced egalitarian behavior (Boehm 1993).

#### **Cross-cultural evidence**

Some of the most prevalent cross-cultural evidence of sharing occurs for large packaged resources, usually wild game, characterized by high acquisition variance. Widespread pooling of large game animals is common among the Hadza (Hawkes 1993; Marlowe 2000), Dobe !Kung (Lee 1972; Marshall 1979), G/wi (Silberbauer 1981), Ifaluk (Sosis 1998), Ache (Kaplan and Hill 1985), Yanomamo (Hames 1990), and Gunwinggu (Altman 1987). While such pooling can significantly reduce variation in daily meat consumption, the outcome of risk-reduction is consistent with all six models, even though risk-reduction is only explicitly incorporated as a goal within the RA and GS framework. This is because widespread sharing of relatively large sized game items, characterized by high within- and across-individual variability in acquisition, can be explained by future reciprocation (reciprocal altruism), demands and threats of hungry individuals (tolerated theft), honest signals of phenotypic quality (costly signaling), and the

Pareto-optimal distribution solution maximizing group benefit (trait-group selection). Because the costs of sharing decrease with increased package size of the resource (assuming diminishing returns), it is not surprising that large package size is a significant predictor of sharing for meat, and other food items such as fruits, cultigens and market foods (Hames 1990; Gurven et al. 2000a, n.d.b.; Nitanishi 1998).

Thus the observation that the sharing of large packages is widespread does not help distinguish between the models discussed above. The empirical findings relevant to understanding which models are most appropriate for explaining much of the variance in sharing within and across groups are generally concerned with three issues: contingency of giving upon receiving, producer control over distributions, and imbalances between families in what is given and received.

### *Contingency*

Contingency is the feature of sharing relationships critical for distinguishing among several sharing models (Rothstein and Pierroti 1988; Hill and Kaplan 1993). *General* contingency requires that all giving be balanced by all receiving, while *specific* contingency requires that giving to specific others be balanced by receipts from those same individuals (Hames 2000; Gurven et al. 2000a). Specific contingency is usually estimated as the correlation between the percentage or quantity of food given by *A* to *B* with the percentage or quantity given by *B* to *A* over some appropriate sample period. Contingency can be measured within food categories, such as meat for meat, roots for roots, or for all food, which includes exchange across food types. In order for reciprocal altruism to be beneficial to a donor, donors should preferentially give to those who are likely to share with them in the future (specific contingency), while CS requires that the prestige-related benefits from signaling outweigh the costs of producing food that is widely shared (general contingency). Neither tolerated theft, kin selection, nor trait-group selection predict that food donations will be conditional upon expected return benefits.

Specific contingency has only been measured for four groups, all of which are in South America—the Yanomamo (Hames 2000), Hiwi (Gurven et al. 2000a), Ache (Gurven et al. 2000b,c), and Pilaga (Henry 1951). Correlations which describe specific contingency for all foods are significantly greater than zero (between 0.2 and 0.5, Gurven n.d.), while within resource categories, contingency is often highest for cultivated and collected foods. These results are most consistent with reciprocal altruism and least consistent with tolerated theft, because tolerated theft predicts that there should be no relationship between giving and

receiving.<sup>2</sup> Among the Ache, however, there is no evidence of specific contingency for wild game over the duration of single foraging trips, nor for game items brought back to the permanent colony. This is inconsistent with reciprocal altruism, unless sharing among the Ache rewards group work effort (cooperative acquisition and mutualism) (see Part III). Nevertheless, further research is needed to determine whether these significant positive correlations imply that the time-discounted value of food returns is sufficient to offset the present costs of giving.

Anecdotal evidence that giving is balanced by future receiving, and that those who don't give don't receive, is found in many traditional societies. As one Maimande explained, "if one doesn't give, one doesn't get in return...some people are specifically excluded from most distributions because they never or only rarely give any of their products to us" (Aspelin 1979:317). Similar anecdotes exist among the Agta (Peterson 1978; Bion Griffin personal communication), Pintupi (Myers 1988), Siriono (Holmberg 1969:45), and G/wi (Silberbauer 1981:463). Although there is an emphasis on peoples' expectations for future receipt in these and other ethnographies, the extent of time depth separating episodes of giving and receiving is often unclear. Indeed, Sahlins' use of the term "generalized reciprocity" was meant to reflect short-term imbalances, especially among kin, that are eventually balanced over the span of peoples' lives.

General contingency or balance has been measured in six societies-Ache (Gurven et al. n.d.b.), Hiwi (Gurven et al. 2000a), Meriam (Bliege-Bird and Bird 1997), Pilaga (our analysis of Henry 1951), Yanomamo (Hames 2000), and Hadza (Hawkes et al. 2001). These studies showed mixed support for general balance. While the lack of specific balance contradicts reciprocal altruism, the presence of general balance is consistent with indirect reciprocity (Alexander 1979; Boyd and Richerson 1989) or costly signaling, where the return benefit to the donor is food. If the return benefit is in another currency, such as increased mating opportunities, then a lack of general balance is not inconsistent with costly signaling.

### *Producer Control*

Reciprocal altruism and kin selection require that producers maintain some control over the distribution of foods they acquire, whereas tolerated theft assumes no producer 'rights'. If producers have no control over the distribution of certain items, then those food items may act as partial public goods (Dowling 1968; Hawkes 1993). Despite observations of widespread game distributions in some groups [e.g. Ache (Kaplan and Hill 1985), G/wi (Silberbauer 1981), Hadza (Hawkes 1993), Western Desert Aborigines (Gould 1980)], several lines of evidence indicate that, producers often maintain significant control over distributions in many, if not most, cultures. First, as shown above, there is often a bias in sharing towards those who shared with

the producer. Additionally, there are clear biases in distributions towards close kin living in other families at the expense of distant kin and unrelated families [Gunwinggu (Altman 1987), Copper and Netsilik Eskimo (Damas 1972), Pilaga (Henry 1951), Hiwi (Gurven et al. 2000a), Kaingang (Henry 1941), Batek (Endicott 1988), Pintupi (Myers 1988), Washo (Price 1975), Yanomamo (Hames 1990), Machiguenga (Kaplan 1994), Ache (Kaplan and Hill 1985; Gurven et al. n.d.b), Ifaluk (Sosis 1997), Basarwa (Cashdan 1985)], and to those participating in the hunting party [Netsilik Eskimo (Damas 1972), Nyae Nyae !Kung (Marshall 1976), Ifaluk (Sosis 1997), Pintupi (Myers 1988), Washo (Price 1975), Mbuti (Ichikawa 1983), Aka (Bahuchet 1990; Kitanishi 1998), Efe (Bailey 1991), Lamalera (Alvard 2001), NW Coast Indians (Gould 1980)]. Among the Hiwi and Ache at the settlement, there are clear kin biases in sharing, even when controlling for residential distance. Finally, several ethnographies are explicit about the ownership of shares after an initial distribution, even if others still have not received any meat [Efe (Bailey 1991:100); Nyae Nyae !Kung (Marshall 1976:363)].

Second, hunters frequently consume portions of kills (e.g. internal organs and marrow) at the kill site, and usually “no one begrudges them this right” [Batek (Endicott 1988); Hadza (Marlowe in prep); Nyae Nyae !Kung (Marshall 1976), G/wi (Silberbauer 1981)]. Third, producers often keep significantly more than  $1/n$  of the game packages they acquire, even though others in the camp or village may not possess any meat [(Gunwinggu (Altman 1987); Yora (village) (Hill and Kaplan 1989); Yuqui (Stearman 1989); Yanomamo (Hames 2000); Hadza (Hawkes et al. 2001); Ache (village) (Gurven et al. n.d.a), Hiwi (Gurven et al. 2000a)]. Finally, the frequent observations of incessant “demands” for food in many foraging societies (Peterson 1993; Chagnon 1983) does not mean that producers are powerless to ignore or reject requests for food made by other group members. There is evidence that non-producers do not possess automatic claims to shares among the Pintupi (Myers 1988), the Aka (Bahuchet 1990:38), Agta (Griffin 1984), Pilaga (Henry 1951), and Sirionó (Holmberg 1969:88).

#### *Imbalances: relative need, bargaining, and signaling*

Several ethnographies have reported large short-term between-family imbalances, but long-term balance in food transfers, consistent with generalized reciprocity [e.g. Batek (Endicott 1988:118); Kaingang (Henry 1941:101)]. While short-term imbalances are relatively easy to measure, the existence of long-term balances “in terms of lifelong symbiosis” is much more difficult to confirm. Nepotistic food sharing based on kin selection can predict imbalances in food sharing, even though kinship is a symmetrical relationship. Food given to dependent and unskilled offspring and relatives can have a large benefit at a relatively small cost to a skilled

producer ( $B > C$  in Hamilton's inequality). Similarly, the downward flow of food provides useful calories to younger kin of higher reproductive value (Rogers 1993). Over the course of an individual's lifetime, current evidence suggests that among the Ache, Piro, Machiguenga, and perhaps other traditional groups, children are net costs to parents, and thus children's debt is never repaid directly, but is instead redirected to grandchildren (Kaplan 1994; see Part II). We should expect to find smaller short-term imbalances in transfers among kin of similar age. Allen-Arave and Gurven (in prep) find that among Ache, imbalances over a four month sample period are smaller among kin of similar ages (e.g. siblings) than among kin of disparate ages (e.g. parent/offspring).

Apart from kinship, there is good evidence that large short-term and long-term exchange imbalances among individuals and families occur among foragers and forager-horticulturalists. The highest food producers among the Ache, Efe, Pilaga, and Yuqui consistently gave away more than they received, compared to low producers (Kaplan and Hill 1985; Gurven et al. 2000b; Bailey 1991; Henry 1941; Stearman 1989). Indeed, observations that high producing Ache and Hadza hunters often do not receive in-kind compensation for their generosity initially led to the proposition that reciprocal altruism was an inadequate model of human food sharing (Hawkes 1991; 1993).

Imbalances in quantities transferred across individuals or families can be interpreted in several ways. First, the short-term nature of most field studies places an arbitrary horizon on the delayed time for reciprocation, and the sampling bias associated with any brief series of snapshots of inter-family exchange relations is likely to result in some degree of imbalance. Hames (2000) argues that meticulous score-keeping meant to insure balance should be found across pairs of distantly interacting individuals, where trust is weak (e.g. market transactions), while imbalances might be quite common among individuals who interact over extensive time periods.

Second, an imbalance may be intentional if sharing is based on signaling phenotypic or genotypic quality. Imbalances in turtle meat exchanges, where hunters expend a great deal of energy to provide community feasts, are most likely due to costly signaling (Bliege Bird and Bird 1997; Bliege Bird and Smith 2000). Similarly, an imbalance is expected if the return benefits of reciprocal altruism or costly signaling are in other currencies. High producing Ache hunters may give away more than they receive, but they obtain greater mating opportunities and higher offspring survivorship (Hill and Hurtado 1996). Yuqui and Tsimane hunters sometimes trade portions of their kills for garden products (Stearman 1989; Chicchón 1992), while Kuikuyu with unsuccessful gardens will trade labor for access to neighbor's manioc patches (Carneiro 1983).

As mentioned above, contingency estimates well below 1.0 suggest a relatively high occurrence of exchange imbalances among pairs of families. It is important to mention that all measures of contingency are based on *quantities* of food shared among families. Bargaining theory, however, can lead to outcomes consistent with reciprocal altruism but inconsistent with strong balance in food quantities (Stahl 1972; Hill and Kaplan 1993; Sosis et al. 1998; Gurven et al. 2000a). If donors continue giving portions to others as long as the expected future benefits outweigh the current costs of giving relative to other options, there is no reason to expect the exchange of equal quantities over time. The extent of imbalance should be a function of differential wealth holdings, influence, status, and need. One calculation of contingency that measured the balance in “value” transferred across families, by incorporating the frequency and sizes of shares, found a slightly higher level of balance among Hiwi and Ache foragers (Gurven in prep).

There has been much written on the importance of “need” and the direction of food flows (Woodburn 1982; Barnard and Woodburn 1988; Winterhalder 1996), supporting the notion that “if there is hunger, it is commonly shared” (Marshall 1976:357) and possibly the GS hypothesis. Among Ache, Maimande, G/wi, and Hiwi, shares are often given in proportion to the number of consumers within the recipient family (Gurven et al. n.d.b; Aspelin 1979; Silberbauer 1981; Gurven et al. 2000a). Batek families with high dependency tend to be net consumers while those with low dependency are net producers (Cadelina 1982). There is additional evidence that older men, with larger families, preferentially benefit from sharing networks at the expense of younger men’s labor, especially if one considers brideservice payments [Efe (Bailey 1991), Gunwinggu (Altman 1987), Kutse (Kent 1993), Yanomamo (Ritchie 1991), and Agta (Bion Griffin 1984)]. Differential need among families leads to different costs and benefits of giving across families, and should therefore influence bargaining outcomes and observed levels of balance. We explore this issue further in Part II.

Although certain levels of imbalance may be due to differential need, there is much evidence to suggest that such imbalances are sometimes tolerated only within limits. Those who do not produce or share enough are often subject to criticism, either directly or through gossip, and social ostracism. Anecdotes of shirkers being excluded from distributions until they either boosted their production or sharing levels are found among the Maimande (Aspelin 1979), Pilaga (Henry 1951:199), Gunwinggu (Altman 1987:147), Washo (Price 1975:16), Machiguenga (Baksh and Johnson 1990), Agta (Griffin 1984:20), and Netsilik Eskimo (Balikci 1970:177). However, other ethnographies report the persistence of long-term imbalances without any obvious punishment, exclusion or ostracism [Chácobo (Prost 1980:52); Kaingang (Henry

1941:101); Batek (Endicott 1988:119)], although these anecdotes suggest that such imbalances are due to a small number of low producers within the group.

*To summarize:* There is substantial cross-cultural evidence supporting the view that reciprocal altruism of some sort underlies much food sharing behavior. First, in many societies producers do appear to exert control over the distribution of resources. Second, although specific contingency of giving upon receiving has been measured in only a few cases, there is evidence over the short-term that people form preferential food sharing partnerships with high rates of giving and receiving, and share less with those who give less (meat sharing in the forest among the Ache is one exception, however). There are also a plethora of qualitative reports, suggesting that giving and receiving are contingent in many or most cultures and in different contexts.

At the same time, persistent imbalances between families in amounts given and received suggest that strict reciprocal altruism cannot account for all food sharing between families. Some of those imbalances may be due to kin selection, costly signaling, tolerated theft, trait-group selection or some combination of the four forces. In the next section, we sketch the importance of food sharing in the evolution of the human life history. We show that the evolved life history of humans required long term imbalances in food flows. We also present a new way to understand imbalances in terms of multi-individual decision processes and long-term mutual benefit.

## **Part II. Human Life History and Food Sharing**

### *Features of our human life history*

The distinctive life history of humans is related to their unique foraging niche relative to that of other mammals and even primates. Five distinctive features of the human life course are noteworthy: 1) an exceptionally long lifespan, 2) an extended period of juvenile dependence, 3) support of reproduction by older post-reproductive individuals, 4) male support of reproduction through the provisioning of females and their offspring, and 5) a large brain and its associated capacities for learning, cognition and insight. Humans have a very flexible foraging strategy, consuming different foods in different environments, and this flexibility has allowed us to survive successfully in all of the world's terrestrial environments. In another sense, however, the human foraging niche is very specialized. In every environment, human foragers consume the largest, most nutrient-dense, highest-quality, and most difficult-to-acquire foods, using techniques that often take years to learn (Kaplan et al. 2000).

This foraging niche is related to the life history because high levels of knowledge, skill, coordination, and strength are required to exploit the suite of high-quality, difficult-to-acquire resources humans consume. The attainment of those abilities requires time, a significant commitment to development and a large brain to support the learning, information processing and planning underlying those skills. This extended learning phase during which productivity is low can be compensated by higher productivity during the adult period, and subsidized by an intergenerational flow of food from old to young. Since productivity increases with age, the time investment in skill acquisition and knowledge leads to selection for lowered mortality rates and greater longevity, because the returns on the investments in development occur at older ages.

There are three foraging groups (Ache, Hadza and Hiwi) and two groups of forager-horticulturalists (Machiguenga and Piro) for whom quantitative data are available regarding age-profiles of food consumption and production. All of these groups display similar age-profiles of net food production. Children are largely supported by their parents until about age 18 (when food production approximately equals consumption), after which productivity rises steeply through the 20's until the mid-30's. The more skill-intensive the task, the greater is the delay to peak performance and the greater the increase in productivity with "on-the-job-training" (Bock 2001). High productivity is maintained until the mid-60s when the deleterious effects of senescence become significant. This pattern of development and aging bears a striking resemblance to modern societies, where wages depend on education-based capital, and the ages 18 and 65 have similar significance.

Figure 1 shows survival probabilities and net production by age for wild chimpanzees, our closest living relatives, and modern human hunter-gatherers living under conditions similar to our evolutionary past (see Kaplan et al. 2000; 2001 for details on data sources). It is evident that the chimpanzee net production curve shows three distinct phases. The first phase, to about age 5, is the period of complete to partial dependence upon mother's milk and of negative net production. The second phase is independent juvenile growth, lasting until adulthood, during which net production is zero. The third phase is reproductive, during which females, but not males, produce a surplus of calories that they allocate to nursing. Humans, in contrast, produce less than they consume for about twenty years. Net production becomes increasingly negative until about age 14 and then begins to climb. Net production in adulthood in humans is much higher than in chimpanzees and peaks at a much older age, reflecting the payoff to long dependency. More precisely, human peak net production is about 1,750 calories per day, reached at about age 45. Among chimpanzee females, peak net production is only about 250 calories per day and, since fertility decreases with age, net productivity probably decreases

throughout adulthood. By age 15, chimpanzees have consumed 43% and produced 40% of their expected lifetime calories, respectively; in contrast, humans have consumed 22% and produced only 4% of their expected lifetime calories!

Figure 2 plots net expected *cumulative* productivity as a function of age. This measure involves multiplying the probability of being alive by the net productivity at each age and then cumulating over all ages up to the present. The long human training period is evident when the troughs in the human and chimpanzee curves are compared. The dashed line is a hypothetical cross of human production profiles with chimpanzee survival rates and shows that the human production profile would not be viable with chimpanzee survival rates, since expected lifetime net production would be negative.

These results imply a highly structured life course in which physiological and behavioral processes are coordinated. The greater proliferation of neurons in early fetal development among humans, as compared to monkeys and apes, has cascading effects, extending other phases of brain development, and ultimately resulting in a larger, more complex, and effective brain. From a behavioral point of view, although cognitive development is largely complete among chimpanzees by about 8 years of age, formal abstract logical reasoning does not emerge in humans until age 16 to 18. This is the age when productivity begins to increase dramatically among human foragers.

#### *The evolutionary role of sharing*

A central thesis of this paper is that the human life course could not have evolved without long-term imbalances in food transfer within and among families. First, it is clear from the above figures that if children are eating more than they produce for some 20 years, those deficits must be subsidized. Surplus food provided by older people and those with few dependents can be utilized to finance this long developmental period.

Second, those data represent average production and consumption by age, combining data from both sexes. Men and women, however, specialize in different forms of skill acquisition with correspondingly different foraging niches and activity budgets, and then share the fruits of their labor. The specialization generates two forms of complementarity. Hunted foods acquired by men complement gathered foods acquired by women, because protein, fat and carbohydrates complement one another with respect to their nutritional functions (see Hill 1988 and Hames 1989 for a review) and because most gathered foods, such as roots, palm fiber and fruits are low in fat and protein (nuts are an exception). The fact that male specialization in hunting produces high delivery rates of large, shareable packages of food leads to another form

of complementarity. The meat inputs of men shift the optimal mix of activities for women, increasing time spent in childcare and decreasing time spent in food acquisition. They also shift women's time to foraging and productive activities that are compatible with childcare and away from activities that are dangerous to them and their children.

There are data on the productivity of adult men and women for ten foraging societies (see Kaplan et al. 2000 for details). On average, men acquired 68% of the calories and almost 88% of the protein; women acquired the remaining 32% of calories and 12% of protein. After subtracting their own consumption, women supply only 3% of offspring's consumed calories (31% of total calories), while men provide the remaining 97%! Men not only supply all of the protein to offspring, but also the bulk of the protein consumed by women. This contrasts sharply with most mammalian species (>97%), where the female supports all of the energetic needs of the offspring until it begins eating solid foods (Clutton-Brock 1991) and males provide little or no investment.

In addition to specialization among men and women, specialization in productive activities by age is equally important. Foragers and forager-horticulturalists typically assign low skill/low strength activities (such as collecting fruits or fetching water) to children, high strength/high skill activities (such as hunting and extractive foraging) to prime-aged adults, and low strength/high skill activities (such as child care and craft manufacture) to elderly people (Bock 1995, 2000, Gurven and Kaplan n.d., Kramer 1998). In this way, family returns from labor are maximized. It also appears to be the case that there is some specialization in activities within age-sex classes. Although this is less well documented, anecdotal reports suggest that some men spend more time gathering or farming and others more time hunting [Tsimane (Chicchón 1992; Yuqui (Stearman 1989)], and there is even specialization in hunting roles and in prey types pursued.

There are also imbalances between families that support this intensive mothering characteristic of human life histories. Figure 3 compares the acquisition of calories and reproductive status of baboons (Altmann 1980) with Ache foragers (Hill and Hurtado 1996). Time spent foraging during the day is presented in relation to reproductive status for female baboons, where foraging time includes both travel and feeding time. Baboon mothers are hard pressed to meet the demands of lactation. When they must produce energy beyond their own maintenance needs, their daily time budget is stretched to the limit. They cannot afford to increase their travel time, which would be energetically costly, especially since they must carry their infants. Instead they increase their feeding time by reducing resting and socializing to about 15% of the day. Mother baboons thus work harder. In fact, female baboons have higher

mortality rates when lactating than when cycling or pregnant (Altmann 1980).

In contrast, when lactating and even when they have dependent juveniles to be fed, Ache, Efe, and Hadza women reduce their time spent foraging for food (Hurtado et al. 1985; Ivey 2000; Hawkes et al. 1997). It appears that human females are able to reduce time spent in energy production when they are nursing even though their caloric consumption and dependency load may have increased (ignoring the additional calories of women's milk). Among the Ache, most of women's food production is derived from pounding the pulp of palms to produce starch. About 60% of the starch that women produce on extended foraging trips is shared outside the nuclear family (Kaplan and Hill 1985) with no bias towards close kin. Since lactating women produce much less palm starch than women without a baby, this pattern of sharing means that there are net food transfers from women to other women over periods of several months to several years.

Third, and most important for the present discussion, even with such extensive cooperation within families, additional flows between families are necessary to support this life history pattern. The fact that parental provisioning does not cease when children are weaned means that the caloric burden on parents increases as they produce more children. The bottom part of Figure 4 shows how the net demand on Ache parents changes with age as they produce additional children (viewed in terms of the man's age and scaled on the right y-axis). Demands peak between 40 and 50 years of age and remain significant until age 60. Even though food production increases with age to about age 35-40 and remains high, demands increase faster than food production. The top panel of Figure 4 shows how net food production (calories produced minus calories consumed by self and offspring, plotted on the left y-axis) changes with the age of the man<sup>3</sup>. These data show that there must be net transfers from the families of younger men to the families of older men! Moreover, there is a great deal of variance among men in both family size and productivity (note the size of the standard deviations for this age profile). Family size is inherently stochastic, due to both infant and child mortality and to individual differences in fecundity (see Hill and Hurtado 1996). There are also large differences in hunting ability among men. For example, there is a five-fold difference in the long term average hunting returns between the best and worst hunter in the sample of Ache men (Hill et al. 1987). Similar discrepancies in hunting ability across men have been found among the !Kung (Lee 1979), Hadza (Hawkes et al. 2001), Hiwi (Gurven et al. 2000a), Gunwinggu (Altman 1987), Agta (Bion Griffin 1984), and Machiguenga (Kaplan unpublished data)<sup>4</sup>. Therefore, even among men of the same age, there must be net transfers over the long-term from families producing a surplus to families producing a deficit.

These food transfers provide great reproductive benefits. The ability to 'borrow' and 'lend' across the life course is necessary for subsidizing the juvenile learning period. If families had to 'balance their budget' at every period, they would either have had to lower their fertility or force their older children to fend for themselves. This would most likely increase childhood and adolescent mortality and lower rates of skills acquisition. Adolescent males could not afford to hunt, because their returns are so low during the learning period. Moreover, there would be no way to buffer the risks associated with the stochasticity of family size and child demands. If families needed to support all of their individual food needs, regardless of whether few or many children survived, they would be forced to lower fertility or reduce child subsidies. Similarly, the ability of women to shift production across time without changing consumption probably increases infant survival and decreases the length of inter-birth intervals, thereby increasing the total reproductive success of women. When the opportunity costs of food acquisition are high due to the need to care for infants, women may produce less and then work harder when those opportunity costs are low (i.e. when they have no infant to nurse and protect).

#### *The Problem with Dyadic Reciprocal Altruism*

It is unlikely that such a system of sharing would be stable with strictly dyadic reciprocal altruism. Reciprocal altruism will only emerge among self-interested actors if there is repeated interaction that rewards cooperation and punishes defection. In terms of reciprocal altruism, there is no incentive for young or older adults with small families to support older adults with large families. Those older adults with large families will never produce a surplus to 'pay back' those subsidies. The older adults are likely to die before the young adults reach the age in which they need assistance to support their families. While it might be argued that there is intergenerational reciprocity where the children of the older adults, in turn, support the families of those who helped them, the long time periods between changes in directional flows would make such arrangements inherently risky. There is a great deal of mobility between hunter-gatherer bands and residential arrangements are not stable over long periods. There is no guarantee that children who are helped when they are young will live in the same band as those who helped them. The same argument applies to sharing between non-nursing and nursing women. Additionally, time discounting of benefits received in the distant future relative to the present consumption payoffs from not sharing also makes intergenerational reciprocity unstable (Hawkes 1992).

Similarly, reciprocal arrangements regarding the stochasticity of family size are unlikely to emerge with dyadic relationships. If family size variation is due primarily to random luck, it

may be beneficial for two individuals to agree at the start of their reproductive careers to an arrangement in which the individual who ends up with fewer surviving offspring agrees to support the one with more surviving offspring. However, once the outcome is known, there is no incentive for the one with fewer children to provide the support, since his family will never need the payback and there is no way to enforce the bargain.

Our thesis is that humans have found ways to take advantage of the gains from such trades, even though these gains would not emerge through dyadic reciprocal altruism. We propose that multi-individual negotiations result in the emergence of social norms that are collectively enforced. We base this proposal on a result obtained by Boyd and Richerson (1992), and treated more recently by Bowles and Gintis (2000), in which cooperation is modeled with punishment. They found that cooperation can be stable in large groups, if non-cooperators are punished and if those who do not punish non-cooperators are also punished. In fact, they found that any social norm can be stable as long as both those who disobey and those who fail to punish those who disobey are punished. However, we suggest, in addition, that self-interested actors negotiate those norms, weighing the individual costs and benefits of different social norms.

### *Two thought experiments*

Imagine the following scenario. A woman returns from collecting berries and pounding palm fiber with a bawling infant. A wingless wasp stung her baby while she had put him down to pound the fiber, and is in great pain. She is frustrated and says to the other women in camp, "This is crazy for me to go out and pound fiber when I have such a young baby. I would gladly work twice as hard when he is a little older if I could concentrate on watching him now." A few days later when the wound is infected and the child has a fever, another woman, remembering a similar incident she experienced a few years ago, says, "You know, Singing Deer is right. We should work hard when we have no baby on the breast and allow those with a young one to care for it well." Another woman, who has had no child in the last 10 years, says, "Why should we work to feed other people's babies? If you have a baby, you must feed it." Other men and women consider their own situation and the situation of their children and present their opinions. Eventually a consensus (or at least, an agreement) is reached, with those in the minority either agreeing to go along with the new norm or leaving to live with less foolish people. However, one woman, who is not nursing, hardly pounds fiber at all. Other women begin to gossip about her, remarking upon how lazy she is, because she has no child to care for. She notices that the shares she receives in food distributions start to become less generous and begins to suspect

that others are talking about her behind her back. She leaves and pounds a large quantity of fiber, which she shares generously. She can feel the warmth return and has learned her lesson.

We consider another similar scenario. A fifty year old man exclaims, “Look at these lazy young men! They come back to camp at mid-day and play around. Here I am, and here you and you are with lots of children to feed and no food to give them. What will those boys do when they have big families to feed.” An age-mate agrees, adding “How do I know if that lazy one is good enough for my daughter? How do I know if he will get enough food to keep her children healthy? He should come to my fire and bring me lots of meat, then I will know.” The young men are not so enthusiastic, because they do not like hunting all day long, but they are reluctant to anger the men whose daughters they favor. One young man, who is a good hunter for his age, thinking that he could take advantage of such a system, starts to hunt longer hours, giving the older men generous shares. The other young men, afraid of being outdone, also begin to hunt longer hours, sharing the fruits of their labor.

While admittedly hackneyed, these scenarios are meant to reflect the ongoing discussions and commentaries about sharing, work effort and laziness that are so pervasive in foraging societies. We do not mean to suggest that all social norms are explicitly negotiated with words or that norms solidify over a short period as a result of a few conversations. In some circumstances, lack of compliance and ‘voting with one’s feet’ are almost surely involved in those negotiations. In fact, we know virtually nothing about how standards for appropriate behavior emerge and change in small-scale societies without official means of enforcement. It is likely that majority-rule voting arrangements are not adhered to, in the strict sense, since some individuals exercise undue influence [e.g. *kombeti* among Aka, *kapita* among Efe (Hewlett and Walker 1990), Mbuti, chiefs among Yuqui (Stearman 1989)]. Nevertheless, we propose that such multi-individual negotiations, partly verbal and partly nonverbal, do result in social norms and that the weight of opinion, based upon the individual costs and benefits of norms in given contexts, determines accepted patterns of behavior. In the next section, we develop a preliminary framework for explaining variation in norms regarding cooperation.

### **Part III: A preliminary framework for explaining sharing norms**

We propose that social norms of sharing reflect the relative strengths of two opposing forces: gains from cooperation, and possibilities for free-riding. Socioecological variation in

potential benefits of cooperation and possibilities to free-ride on cooperative behavior determine cultural variability in norms of sharing and cooperative labor.

We also propose that in the course of our evolutionary history, natural selection has shaped our psychology to possess the following traits: 1) perceptual sensitivity to potential gains from cooperation; 2) motivation to take advantage of those gains; 3) perceptual sensitivity to opportunities for free-riding; 4) motivation to avoid being free-ride upon; 5) motivation to take advantage of opportunities for free-riding; 6) perceptual sensitivity to the short and long-term personal costs and benefits of social norms regarding cooperative behavior (from the perspectives of both self and others); 7) motivation to negotiate social norms so that own personal benefits from cooperation and free-riding are maximized; 8) motivation to obey and enforce social norms so that punishment is avoided and those who disobey norms or fail to enforce them are punished.

Our proposal is that this psychology, the complex analytical brain, and the extended life history co-evolved in the hominid line, all because of the dietary shift towards large, high quality food packages and hunting. It is this feeding adaptation that generates the gains from cooperation. The large size of the packages and the difficulty of their acquisition: a) facilitate sharing (imagine sharing blades of grass back and forth); b) increase short-term variation in acquisition luck, since large packages are not abundant; c) require significant learning and experience; d) increase the disparity between production and consumption at the individual and at the family level over the medium and long runs; e) increase the benefits of collective action and cooperative pursuits, especially in hunting, and f) generate economies of scale since foods are often distributed in large patches distant from residential locations.

These qualities generate large gains from intertemporal substitution in consumption and production over the short, medium and long term, gains from specialization by age, sex and perhaps individual qualities, gains from joint production and cooperative acquisition, and gains from turn-taking in acquisition of patchily-distributed foods. The distribution and relative importance of each of those gains is likely to vary with local ecology and the foods exploited.

Possibilities for, and gains from, free-riding act against cooperation. Three factors are likely to influence the threat of free-riding. First, the number of individuals in cooperative networks is likely to increase the threat, because the ability to detect and punish free-riders probably diminishes with partner number. As group size increases, the probability that more than one individual free-rides may also increase (Boyd 1988). As the number of free-riders increases, costs of punishment increase and the incentive to cooperate decreases. Second, the quality of information about behavior is also likely to affect opportunities for free-riding. If work

effort is difficult to monitor and if it is difficult to determine whether variance in productivity is due to acquisition luck or work effort, opportunities for free-riding may increase (Cosmides and Tooby 1992). Third, gains from free-riding are also likely to vary according to kinship relationships between participants. As overall relatedness decreases, the differences among optimal allocations of work and distribution across individuals are likely to increase.

Those opposing forces may have led to the evolution of some general moral sentiments, supported both by the emotional and motivational psychology of individuals, and common cultural norms. Variation in need and production among individuals due to stochasticity should engender generosity, and cultural norms emphasizing the value of generosity, as perhaps mediated through costly signaling and reciprocal altruism. Sharing sentiments and norms would favor those who were unfortunate over the short or long run, requiring generosity from the more fortunate. Virtually every investigator who seeks to establish friendships with members of traditional subsistence populations who are much poorer, feels the pressures associated with those sentiments. Similarly, temporary states affecting production or need, such as illness, nursing, and high dependency ratios, would also promote generosity. As mentioned above, the rule that larger families deserve and receive larger shares is very widespread. Conversely, variation due to lack of effort or laziness would not generate generosity and perhaps invoke ridicule or punishment (unless the effort is reciprocal in the case of economies of scale). Indeed, laziness and stinginess are constant themes for gossip in traditional societies. Other things being equal, people should feel more generous towards, and trusting of, close kin, because of the reduced scope of conflicting interests.

At the same time that moral systems are likely to have such general guiding principles, there is scope for considerable variation in the norms of cooperation and sharing, depending upon the specific constellation of gains from cooperation and possibilities for free-riding. Of critical importance is the relationship between the size and composition of residential groups and the optimal size of cooperating units. In general, people will tend to organize residential groups so that they can take maximal advantage of the gains from cooperation and reduce risks of free-riding. Thus, many forager-horticulturalists in South America, such as the Machiguenga, Piro, and Tsimane, settle in extended family units, characterized by an older couple, their adult sons and/or daughters, and the founding couple's grandchildren. Labor is divided by age and sex, and food is eaten communally. This system of communal production and consumption maximizes gains from specialization and from spreading consumption and production needs through the entire age-structure, while kinship and shared genetic interests in the young children minimize conflicts of interest.

Several factors may cause residential groups to differ in size and composition from their optimal structure for cooperation. Aggregation of larger groups is common, because of threats of violence [e.g. Yanomamo (Chagnon 1983)], patchy resources such as water or groves of trees [e.g. Dobe !Kung (Lee 1979)], and now schools and delivery points of social services [e.g. Chácobo (Prost 1980)]. In these cases, restricted sharing, where some or all foods are shared with only a subset of the residential group, is the norm.

Restricted sharing systems appear to be particularly common when the primary gains from sharing derive from variance reduction in consumption and when gains from cooperative pursuits are small or restricted to only some resources or times of the year. A common principle evidenced in restricted sharing systems is that the breadth and depth of resource sharing depends on the size of food packages. When food packages are small, they are shared to a few special partners, with whom reciprocal sharing is very common. As package size increases, the size of sharing networks (increased breadth) and the percentage of the food kept by the acquirer's family is reduced (increased depth).

Figures 5 and 6 illustrate the features of this system. Figure 5 shows the percentage of sharing events, by resource package size, in which specific families receive shares among Ache at their permanent horticultural settlement. For each individual, sharing partners were rank-ordered from those who received most often to those who received least often. The x-axis displays the rank order and the y-axis gives the average percent of occasions in which partners of each rank received shares. The data show that small packages are repeatedly shared with few individuals, and that the size of sharing networks expands with large packages. Figure 6 (derived from data collected among the Hiwi and adapted from Gurven et al. 2000a) is a path analysis predicting the total accumulation of food transferred between families over a six month sample period, giving additional information about how partners are selected and about the size of shares given. Kinship predicts the spatial proximity between givers and receivers, which, in turn, predicts both how much was received in the past and the amount given. In addition to kinship and proximity, the past history of sharing also predicts the amount given, suggesting that giving is contingent on past receipts when controlling for these other factors. Larger families also receive larger shares, as would be expected if need is being taken into account. Qualitative and quantitative reports from other societies suggest that similar patterns (kin bias, differential rules for sharing different resources with increased breadth and depth of sharing with increased package size, contingency of sharing on the basis of past receipts, and larger shares to larger families) are found in other societies (Ifaluk - Sosis 1997; Eskimo - Damas 1972; Batak - Cadelina 1982; Yora - Hill and Kaplan 1989). It is not always the case, however, that the

residential group is larger than the optimal sharing network for all resources acquired. In cases where very large packages are sometimes acquired (e.g. giraffe among the !Kung), it is sometimes necessary to inform members of neighboring groups about kills because the optimal sharing group size is larger than the optimal residential unit (Lee 1979).

Such systems tend to take advantage of the gains from cooperation while minimizing risks of free-riding. Reducing daily variation in the consumption of small packages requires fewer partners than in the case of larger packages. Thus, a small circle of trusted partners, frequently kin and neighbors, is most efficient. As package size increases, the benefits of a greater number of partners increase, but so too do the costs of free-riding.

Another important principle of restricted sharing systems is that work effort in cooperative activities is rewarded. Thus, when cooperative task groups form, food is often shared equally among the participants. When those task groups do not include members from all the families in the residential group, a system of primary and secondary sharing is very common. In the primary distribution, all participants in the cooperative activity receive approximately equal shares of the total catch (see Part I for a list of groups engaging in this practice). In secondary distributions, each individual that received shares redistributes his or her share to families that did not participate. Those shares are smaller and tend to be shared according to the size of the packages acquired in the manner discussed above. Figure 7 from the Yora illustrates this pattern (see Hill and Kaplan 1989). The first two bars show the primary distribution to members of the foraging party and the second two bars show the secondary distribution. This is an “incentive compatible” system in which work effort is rewarded in the primary distribution and the other benefits of sharing (e.g. intertemporal substitution in consumption and production) are handled in the secondary distribution. In cases where representatives from every family in the residential group become involved in cooperative pursuits, such as Ache when living in the forest and Yora on trek (the third set of bars), food tends to be eaten communally.

In addition to rewarding work effort, sharing systems also appear to reward special capital contributed to cooperative efforts. For example, cooperative fishing and whaling among some coastal groups [e.g., Ifaluk (Sosis 1997), Lamalera (Alvard in press), and Makah (Singleton 1998)], requires boats and large work parties. Again, there is a primary distribution to all those who worked and secondary distributions for further sharing. However, in this case, boat owners receives larger or preferential shares. This suggests that not all individuals are weighted equally in the negotiation of sharing norms. While it is possible that those without boats could form a coalition to enforce equal sharing (since they are greater in number), it

appears that those with special capital have more to offer in the market for cooperative partners and use this leverage to their advantage. Similarly, among Mbuti pygmies who hunt with large nets, net owners receive more food (Turnbull 1965) and, among Efe and Aka Pygmy hunters, food shares depend upon the task performed in the cooperative hunt (Ichikawa 1983; Kitanishi 1998).

Finally, sharing systems undergoing transition also illustrate important principles in the negotiation of sharing norms. For example, the Ache have experienced several changes in food sharing and labor organization, when their economy transformed from full reliance on hunting and gathering in small groups to a mixed economy of foraging, farming and wage labor in larger settlements, following the establishment of permanent peaceful contact with the larger Paraguayan society. For the first five or so years following settlement, agricultural fields were cleared and planted communally. All able-bodied men were expected to contribute labor in large work parties. This pattern resembled the cooperative economy of the past. However, within a few years, it became apparent that some people were often absent from work parties and resentments began to build. Some men tired of this system and cleared their own personal gardens. Communal fields became smaller and a system of private fields, with fewer friends helping each other, came to predominate. Similarly, even with hunted and gathered foods, the system changed from communal sharing of all game to a restricted pattern resembling the Hiwi one shown above. It is interesting to note that the Ache still retain the traditional sharing pattern when trekking in the forest, even though they revert to the new pattern when residing in the settlement. Similarly, the !Kung San appear to have undergone major changes in their system of food distribution, since becoming involved in a mixed economy and the larger state society. Again, the trend seems to be from more communal distributions to more restricted sharing, with a great deal of bickering and strife during the transition (see Shostak (1981) and the associated N/ai film for qualitative accounts).

The transition to horticulture among the Ache and !Kung was very rapid, and encouraged through missionary assistance. As mentioned above, the establishment of private fields was quickly advocated and voted upon in local Ache meetings. This contrasts with the pattern in other groups such as the Hadza (Woodburn 1982) and the Batek (Myers 1988), where initial attempts at horticulture by a minority of the population were met with abrupt failure. The first harvests of the few transitional farmers were exploited by incessant demands of those who did not farm, ultimately making farming an unproductive activity due to mutual adherence to more traditional norms of sharing.

## **Conclusion**

We have proposed that in addition to individual reciprocal arrangements, humans appear to be able to take advantage of gains from cooperation in ways that are unexpected by models of pair-wise games. We suggested that people engage in multi-individual processes of norm negotiation (both verbal and nonverbal) that allow gains from cooperation and minimize risks of free-riding. The framework we proposed, however, is qualitative and is far from fully specified. It clearly requires formal models to evaluate its plausibility.

We suspect that given the absence of state controls, the systems of exchange and cooperation found in traditional societies, would not be stable without the complex web of kinship connections characterizing their residential groups. Those connections have two effects. First, as discussed above, they reduce conflicts of interest between individuals and families. In fact, the marriage alliances between families (observed and commented on since the earliest days of anthropology) may be a way to minimize such conflicts of interest through the production of descendants sharing genes from both sets of families. Second, kinship connections lower the variance in the payoffs associated with norms of sharing and cooperation. For example, norms that allocate larger shares to families with more children to feed may be disadvantageous for individuals in small families, but because, members of small families are likely to have close kin (nieces, nephews, brothers, sisters, and grandchildren) in large families, the total net results of the norm for their genetic lineage may be positive. Since most other species that have elaborate systems of resource sharing and cooperation, such as social insects and group-hunting predators organize cooperation along kinship lines, it is likely that kinship played an important role in the evolution of cooperation in humans. Models of multi-individual norm negotiation with and without kinship will be particularly useful in evaluating this intuition.

In part III, we suggested that norms of sharing and cooperation would reflect the ecology of subsistence and the associated variability in the gains from cooperation and possibilities for free-riding. However, it is possible that similar ecologies may result in very different equilibria, depending upon historical conditions and perhaps even, essentially random perturbations. Formal models would also be useful for evaluating this possibility. If multiple equilibria are possible, then cultural or trait group selection may determine which equilibria come to dominate over time. Given the kinship relations organizing the formation of groups in traditional societies, cultural and genetic selection among groups and lineages may occur simultaneously.

Finally, informal observation (and the results of behavioral genetics studies) suggest that there may be significant individual differences within groups, in the extent of free-riding and

obedience to group norms. The existence of varying degrees of free-riding by individual members of social groups may be an inevitable outcome of cooperative norms that can only be partially enforced. The optimal amount of effort allocated to police free-riding may itself be subject to negotiation, as are allocations to law enforcement in state societies.

This paper represents a first step in a developing a multi-individual approach to cooperation among traditional human societies and to the psychology that underlies it. Our hope is that this paper will help stimulate the development of formal analyses of those processes.

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<sup>1</sup> Chimpanzee mothers do share some difficult-to-acquire solid foods with weaned offspring (Silk 1979), but chimpanzee young are largely self-sufficient after they are weaned.

<sup>2</sup> While computer simulations reveal that significant correlations between individuals in amounts given and received are possible when TT is the sole cause of food sharing, correlations greater than 0.2 were only found in groups of fewer individuals than was common in the above groups.

<sup>3</sup> The consumption and production of women is not included in this calculation since, on average, women produce just enough to support their own consumption or a bit less.

<sup>4</sup> Among the Machiguenga of Yomiwato, the best hunter produced more than half of the meat for the whole village over a year period.

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**Figure 1. Survival and Net Food Production:  
Human Foragers and Chimpanzees**



Note: Adapted from Kaplan and Robson 2000

Figure 2. Cumulative Expected Net Caloric Production by Age:  
Humans and Chimpanzees

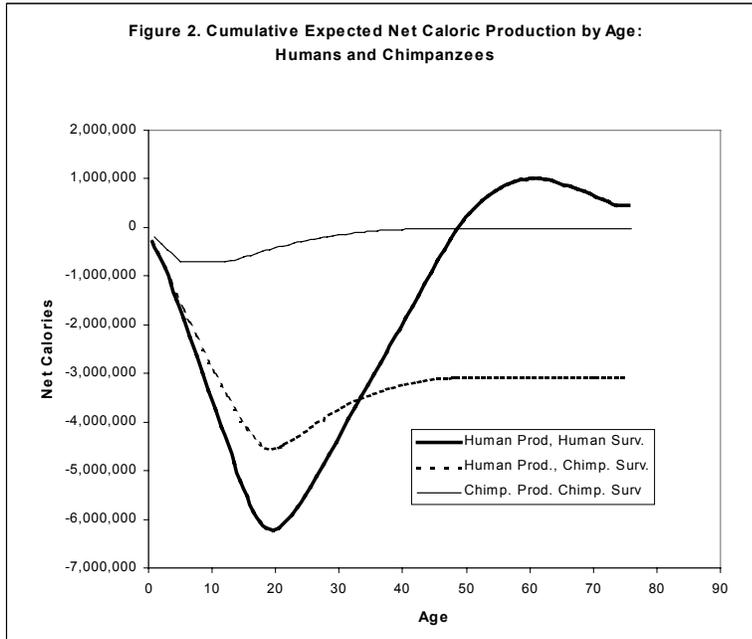
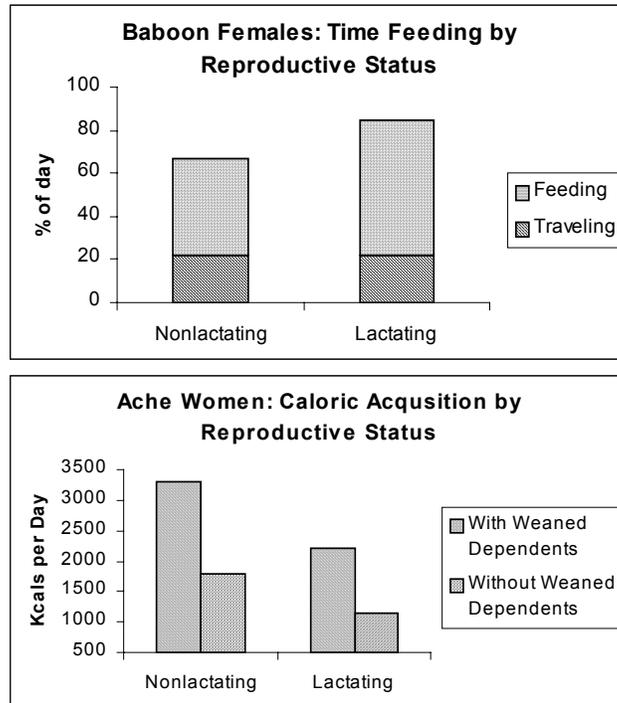


Figure 3. Production and Reproductive Status



Adapted from Lancaster et al. 2000

Figure 4. Family Demands and Net Family Production

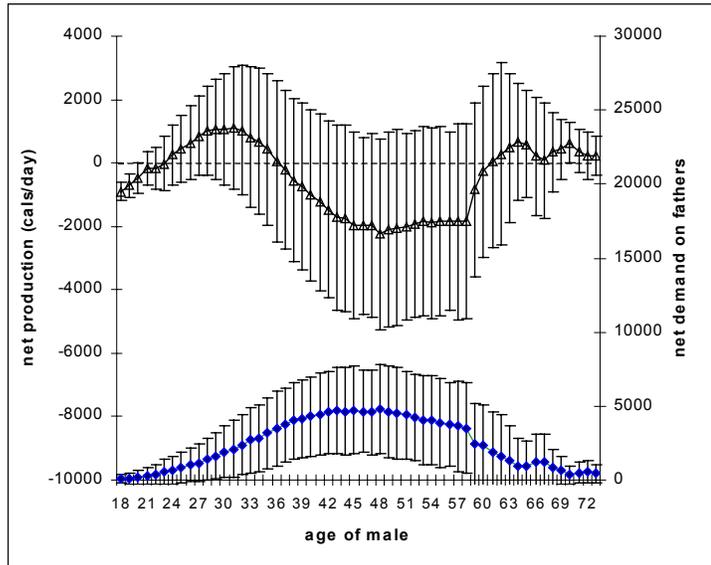
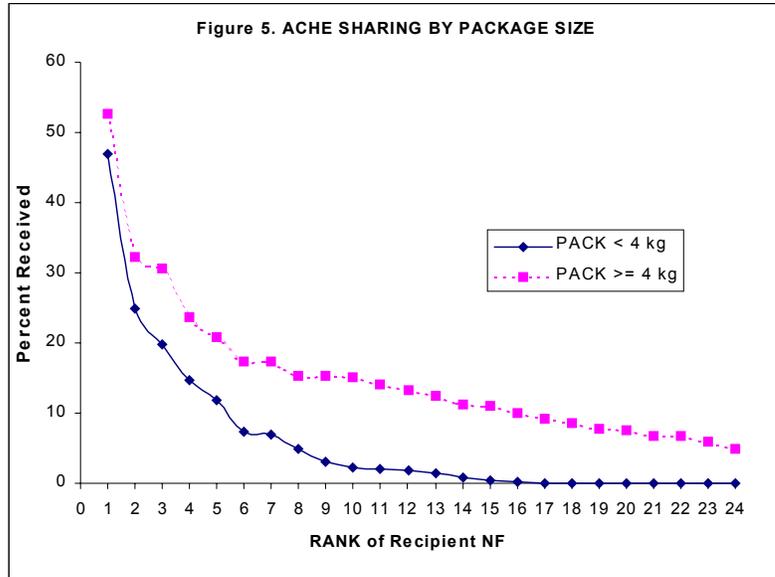
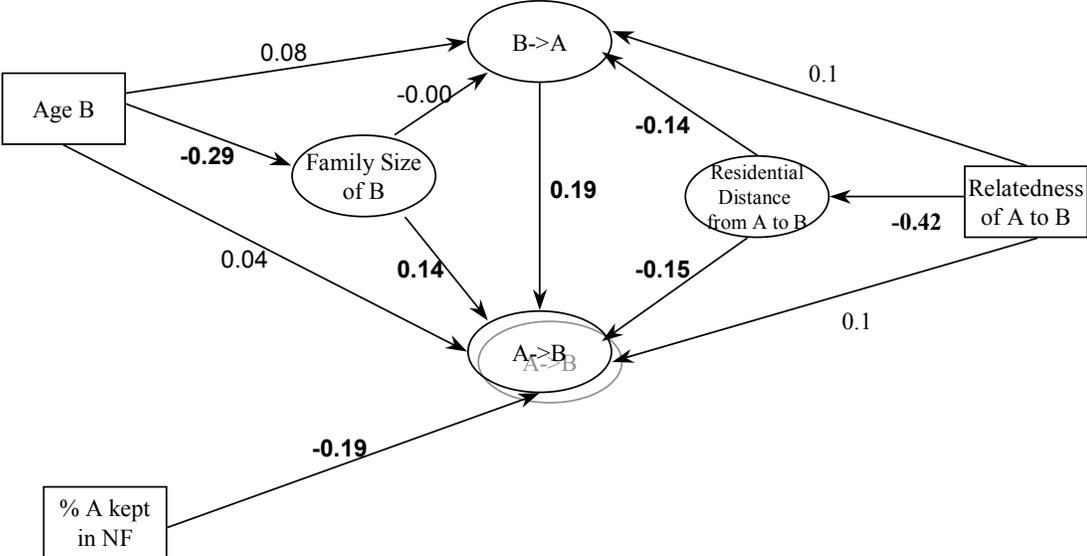


Figure 5. ACHE SHARING BY PACKAGE SIZE



**FIGURE 6.** *What affects how much NF A gives to NF B: Hiwi?*



**Figure 7. Yora Meat Sharing**

