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"It's a Wonderful Life": signaling generosity among the Ache of Paraguay

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Abstract

Intensive food sharing among foragers and horticulturists is commonly explained as a means of reducing the risk of daily shortfalls, ensuring adequate daily consumption for all group members who actively pool resources. Consistently high food producers who give more than they receive, however, gain the least risk-reduction benefit from this daily pooling because they are the least likely to go without food on any given day. Why then do some high producers consistently share food, and why do some average producers share proportionally more food than others? We propose that although these individuals may not receive the same amounts they give (i.e., strict Tit-for-Tat), one explanation for their generosity is that they receive additional food during hard times. These include brief episodes of sickness, disease, injury, or accidents—fairly common events in traditional societies that can render individuals incapable of producing food, thereby having long-term effects on morbidity and fecundity and ultimately on lifetime reproductive success. Data collected among the Ache, a group of South American forager-horticulturists, indicate that those who shared and produced more than average (signaling cooperative intent and/or ability to produce) were rewarded with more food from more people when injured or sick than those who shared and produced below average. These results, framed within the context of tradeoffs between short-term and long-term fitness, may provide insight into motivations behind costly expenditures for establishing and reinforcing status and reputation.

Keywords: Hunter-gatherers; Food sharing; Status quest; Reputation; Generosity; Altruism

> Bert: "He never thinks about himself, God; that's why he's in trouble."
>
> Uncle Billy: "Mary did it, George! Mary did it! She told a few people you were in trouble and they scattered all over town collecting money. They didn't ask any questions—just said: 'If George is in trouble—count on me.' You never saw anything like it."
>
> *–It's a Wonderful Life*

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1. Introduction

An important sociobiological question addressed by many observers of human and nonhuman behavior over the past 30 years is: *Why do individuals give away valuable fitness-enhancing food resources to other individuals*? Answers vary but generally fall into one of several categories: nepotism (Hamilton, 1964), reciprocal altruism (Trivers, 1971; Rothstein and Pierroti, 1988), or tolerated theft (Blurton Jones, 1987; Winterhalder, 1996). A number of quantitative studies in traditional populations highlight the importance of several of these models in explaining patterns of food transfers under different ecologies (Yanomamo: Hames, 1990, 2000; Gunwinggu: Altman, 1987; Ache (forest): Kaplan and Hill, 1985; Hawkes, 1991; Ache (reservation): Gurven et al., submitted; Hadza: Hawkes et al., n.d.; Hiwi: Gurven et al., 2000). Although it now is recognized that any complete explanation of variation in the vast repertoire of social behavior falling under the label "food sharing" requires some combination of these models (Winterhalder, 1997), there is still a great deal of food sharing behavior that does not appear to be explicable by *any* of the models (Gurven et al., 2000). In particular, instances of food sharing that appear to function as status display by the acquirer are not readily explained by any of the models.

In this paper, we discuss implications of having a *reputation for generosity*, a feature of human behavior familiar to ethnographers working in both traditional and modern populations, but a feature with little developed theory.

1.1. Reputation

Two potential benefits to good hunters who share food include higher offspring survivorship due to extra attention received by other band members (Kaplan and Hill, 1985) and increased number of mating partners (Kaplan and Hill, 1985; Hawkes, 1991, 1992, 1993). Whereas the sharing of large high variance game by men is viewed by Kaplan and Hill as trade via reciprocal altruism, Hawkes proposes that this sharing is "showing off"; she construes mens' focus on targeting these resources as a form of mating effort in a social setting where acquirers have little or no control over the distribution of food they acquire and where denying others access is not worth the cost. In stratified societies, Boone (1998) equates the signaling of high status with high social power and privileged access to resources during catastrophic stress periods (e.g., crop failure). Sugiyama and Chacon (2000) have argued that among forager-horticulturists, those with costly to-replace skills (e.g., the best hunters) consistently distribute meat resources to individuals as a means of securing food during down periods caused by significant illness or injuries. All approaches invoke the "quest for status" without explicitly defining the qualities or intentions being advertised, the precise process by which high status yields worthwhile privileges, or how status is acquired and maintained. Our approach contains elements of the works by Sugiyama and Chacon and by Hawkes, but focuses instead on the control of generous behavior and its interactions with production ability.

We use the term *reputation* rather than status in this paper because reputation depends on a specific set of characteristics that an individual advertises to provide an intended (or sometimes unintended) impression of "self" in the minds of others. Thus, reputations for different traits may each lead to high status. Understanding the investments that individuals make in their reputations require investigation of three fundamental questions: (1) What are the displays that lead to a given reputation, and how are these linked to the beliefs that others have about the signaler? (2) How reliable are reputations over time, and what are the patterns of investment necessary for the maintenance of a given reputation? (3) What is the appropriate time scale of fitness returns, and how does the potential for benefits at this scale trade off against short-term benefits from alternative behaviors? This paper focuses directly on the third question and only indirectly on the first two.

The third question addresses the long-term payoffs of reputation. Given time discounting of future rewards weighed against the potential for immediate gain, it has been argued that reciprocal altruism is an unlikely explanation for food-sharing behavior (Hawkes, 1992, 1993). In order for a reputation for generosity to payoff via reciprocal altruism, payoffs received in the future should have higher net present value than the short-term benefits obtained from hoarding. If current losses are traded off against immediate returns, methods need to be specified that ensure long-term success. These issues are discussed in the context of food sharing in the next section.

1.2. Food sharing as an honest signal of intent and quality

Food sharing may be useful as a means of acquiring reputations for generosity and for high productivity. While the origin and maintenance of any food sharing in modern hunter-gatherers might be explained by other outcomes such as the risk-reduction benefits of pooling the daily catch of difficult-to-acquire resources, some of the current variation in sharing behavior across age and sex classes within and among different groups, such as the Ache, the Hadza, and the Hiwi, might be explained by differential payoffs from display sharing across these categories. Many biological displays take advantage of prior sensory and behavioral adaptations of potential recipients, such as the leg vibrations or "courtship trembling" of male water mites, which attract females who normally ambush copepod prey that they detect from copepod swimming vibrations near the surface of the water (Proctor, 1991). Analogously, the existence of food sharing for reasons other than display would seem to be a prerequisite for food-sharing–based reputations.

We propose that some food sharing may act as a signal of both intent and quality. Individuals who consistently share food intensively (especially when it is not efficient to do so due to short-term gains of consumption) signal a willingness to cooperate with specific partners when food is consistently shared with these individuals. This intent can be useful for securing trade relationships, forming coalitions, and generating allies in disputes. If food is intensively shared with the same groups of people over time, this could signal both high productive ability and intent to cooperate with those people; if food is shared inconsistently with different groups of people, this might only reliably signal high productive ability. The signal is honest because only high producers can consistently give away a large proportion of their production and still support themselves and their families. When there is a high baseline level of food sharing among individuals in a population, display sharing can be any sharing above and beyond the "average" level. This means giving away a larger proportion of acquired resources than are usually given and/or to more people than normally received.

It is important to realize that not all food transfers are equally costly. The degree of costliness depends on the intrainidividual and interindividual acquisition variance of the resource and the relative productive ability of the donor. For the Ache, meat is a valued commodity and the distribution of meat should be most suspect for finding evidence of display sharing. Wide sharing of certain cultivated resources such as manioc, which is available in abundance, might reveal a willingness to cooperate and could signal quality only in the sense that donors work enough in their own fields that they can freely give away (or allow others to harvest) portions to other individuals.[1]

It is proposed that long-term benefits accrue to generous individuals who establish and maintain a reputation for generosity and/or high productive ability. A generous individual is more likely to be favored as a partner in a cooperative relationship such as reciprocal sharing, labor exchange, and trade (e.g., exchanging food for hunting tools). The value of generosity, however, is closely linked to production, because the expected amount of food an individual can expect to receive will be the product of a willingness to share and the amount acquired. Holding generosity constant, better producers also should be favored as partners in similar relationships as well as mates. Signaling both high quality and intent to cooperate is likely to produce any of these benefits. Here we investigate one avenue of potential return benefits from establishing and maintaining a reputation.

1.3. It's a Wonderful Life (or not-so-instant karma) model

Even the most consistent producers in traditional populations are subject to bouts of illness, disease, insect and snake bites, injuries, and accidents that can prevent them from engaging in productive activities for brief periods of time, or can at least depress rates of return gained from subsistence activities. Preliminary health studies with the Ache living at the Arroyo Bandera reservation show that, over a 3-month period, Ache adults were sick roughly 6.5% of all days (A.M. Hurtado, unpublished data). Among the Yora of Peru, the rate of sickness and injury for adult males was 8%; for all males and females, the rate was 5.5% (Sugiyama and Chacon, 2000). Among the Efe Pygmies of Ituri Forest, Bailey (1991) reports that Efe men and women complained about some ailment on 21% and 22% of all sample days, respectively. A large proportion of the ailments (63%) were trauma caused by sores on the soles of feet, thorns, hernia, and accidents. Regarding the importance of these and other ailments, Bailey writes that "if he were working in this country and had the same level of morbidity as found in this sample, an Efe man would call in sick approximately one day per week" (p. 62).

The prevalence of these hazards can prevent individuals from producing food for lengthy periods of time (Sugiyama and Chacon, 2000). Thus, there is a strong impetus for ensuring adequate nutrition to disabled individuals during their time of greatest need. We propose that when temporary disability strikes individuals under conditions of no food storage, able-bodied individuals are more likely to provide food and support to those who have strong reputations for being generous and who are high producers. We can call this the "Bailey effect" after the character George Bailey in the 1946 film *It's a Wonderful Life.* Bailey puts everyone

[1] "Good" hunters and "good" farmers can both signal high productive ability, although successful farmers might owe their success to their own high time investment (and less to skill), and successful hunters may owe their increased success to developed skills and better physical condition.

else's needs and desires before his own, until a streak of bad luck leaves him destitute. At the brink of despair, George Bailey receives abundant financial help from everyone in the local community, who extol his reputation for generosity.

Even if these "down" periods are infrequent, getting food and proper care during them can be essential to prolonged survival and future reproductive success. For example, a lack of adequate nutrition (especially protein and fat) among humans during bouts of physical trauma can lead to prolonged disability (Blackburn, 1977; Chang et al., 1998), stunted growth rates (Kabir et al., 1998; Jackson, 1990), increased morbidity (Bonjour et al., 1997), delayed age of menarche (Maclure et al., 1991) and decreased female fecundity (Bringer et al., 1990; Barr et al., 1994).

In the Appendix, we present a formal model illustrating one way that investments in reputations can produce return benefits to the signaler and then demonstrate how the model works through a series of simulations. The model allows four strategies that vary in their production ability and generosity: (a) *philanthropic* individuals (like George Bailey) produce a lot (quantity H) and give away a large proportion (s_g) of their total production; (b) *means-well* individuals produce little (quantity L) and give away a large proportion (s_g) of their total production, (c) *greedy* individuals (the selfish banker Mr. Potter in *It's a Wonderful Life*) produce a lot (quantity H) but share a small proportion (s_s) of their total production; and (d) *ne'er-do-well* individuals produce little (quantity L) and similarly share a small proportion (s_s) of their total production.

There are two important conclusions of the model. First, simple compensation in the form of additional food to generous individuals during down periods makes a reputation for generosity a successful, long-term strategy under a wide range of conditions. Second, compensation to generous individuals during down periods does not constitute a second-order collective action problem if the marginal benefit of individual aid to the injured individual, and the expected gain from that individual upon recovery, are sufficiently high (see Appendix).

1.4. Predictions

The model suggests that the rewards accrued during down periods by those with reputations for generosity or production ability (or both) make continual investment in those reputations worthwhile in the long term. In exploring how reputations based on generosity or on production ability can lead to aid during down periods, we make two testable predictions to explore among the Ache.

1. Generous individuals should receive more food when unable to produce than stingy individuals, holding production ability constant. This implies that generous individuals should receive more food from each helper, the same amount of food from more helpers, or more food from more helpers.
2. Holding reputation for generosity constant, those who produce more should receive more food than those who produce less. Again, this implies that high producers should receive more food from each helper, the same amount of food from more helpers, or more food from more helpers.

2. Methods

2.1. The Ache

The Ache of eastern Paraguay were full-time hunter-gatherers occupying a 20,000-km^2 area of the upper Jejui watershed up until the time of contact in the mid-1970s. Although they currently reside on permanent settlements, they continue to spend up to 33% of their time on extended foraging trips (Hill and Tikuarangi, 1998). Many aspects of hunter-gatherer socioecology, including foraging behavior, time allocation, food sharing, reproductive strategies, and life history, have been well studied among the Ache over the past 15 years (review in Hill and Hurtado, 1996). To date, only one study has focused on differences in time allocation and subsistence behavior between the mobile foraging and sedentary reservation contexts (Hawkes et al., 1987).

2.2. Study population

Arroyo Bandera ("Flag Creek") was formed in 1980 when a group of Ache left the Chupa Pou settlement to live on the edge of a Guarani Indian reservation administered by Protestant missionaries (Hill and Tikuarangi, 1998). It is located 1.5 km from the western border of the Mbaracayu Reserve, where the Ache maintain exclusive access and continue hunting and gathering. During the study period from January to May 1998 (wet and early dry season months), there were 117 permanent residents (34 adult men aged 16 and older, 25 adult women aged 16 and older, 24 boys, and 34 girls) within the community, living in 24 nuclear family-based households. The houses were small wooden board structures (constructed within the past 2 years), situated in a circular fashion around a small soccer field, with the average distance between any two households being about 108 m (maximum distance 242 m).

2.3. Data collection

Food distributions ($n = 380$) were sampled using a combination of random time blocks (78% of all distributions), focal resource follows (10%), and interviews (12%). Time blocks were completed on random clusters of households over a random 3-hour time span (7–10 a.m., 10–1 p.m., 1–4 p.m., or 4–7 p.m.) and thus constitute a random sampling of food distributions and resources. Resource follows and interviews were conducted to obtain sharing data on less common resources unlikely to be sampled using the time blocks, such as forest foods brought back to the reservation and large domesticated animals.

For each resource distribution, we recorded the identity of the donor, the original acquirer, and all recipients, and we estimated the total resource package size and amounts given to each recipient. Amounts were either weighed using 10-kg and 25-kg Homs spring scales or counted (as in sticks of manioc) and then converted to kilograms by using unit weight measurements of counted resources. Furthermore, we subdivided events into *source* distributions and *subsequent* distributions. Source distributions ($n = 228$) describe the original distribution of a resource, where the acquirer and the donor are members of the same nuclear family. Subsequent distributions ($n = 152$) are any distributions where the acquirer and donor are members of different nuclear families.

Information on assistance while sick or injured was obtained through interview. We asked all available adult Ache to recall the "last time they were so hurt that they had to stay in bed" and asked them to recall (a) the number of days they were hurt, (b) the symptoms of their discomfort, (c) the names of all individuals that gave them food while disabled, and (d) the foods given by each individual.

2.4. Variables

The response variable detailing the form of compensation was quantified in several ways: the number of individuals that gave food to each disabled individual, the number of individuals outside the nuclear family of the disabled that gave, the percent of donors that were outside the nuclear family, the total number of food items received, and the total number of meat items received.

The predictor variables reflect "generosity" and "productivity." Both of these variables are binary, reflecting only low and high amounts of sharing and productivity. The generosity variable was formed by placing all individuals who gave away a percentage of their total production higher than the median level (87% of individual production) into the "gave a lot" category, and all those who gave away less than the median level into the "gave little" category. The productivity variable was formed by ranking all individuals according to production totals taken from the random time blocks, then labeling the upper quartile as "high producers" and the remaining as "low producers." We used the upper quartile as the definition of "high producer" because the productivity of the upper quartile was much higher than that for the remaining nuclear families.

3. Results

Of the 50 adults interviewed, 11 claimed that they had not recently been "so hurt that they had to stay in bed". The median duration of sickness among all interviewees was 3.5 days, and incapacitating sickness events described occurred at a median of 30 days prior to the interview. Of the 39 events described, 61% were some form of sickness (stomach pains, cough, fever, headaches, and lung pains), 26% were injuries (ankle, arm, back, knee, shoulder, and hand), and the remaining 13% were recent birthing episodes. Of the 113 food items listed as having been received while disabled, 67% were carbohydrate reservation foods, 29% were meat (forest and domesticated), and 3% were fruit. This contrasts with the normal Ache diet at the reservation, which through preliminary analysis appears to include less meat (10% of total kgs consumed) and more carbohydrates (80% of total kgs consumed).

3.1. By sex and age

Means, standard errors, and ranges for the response variables for the sample population are given in Table 1. On average, an adult Ache disabled for about 3 days received 3.3 food items (0.7 meat items) from 2.4 people (1.7 of whom were from individuals outside the nuclear family). Table 1 also gives the means by sex and age category ($\leq$35 or $>$35 years old). Few of the differences by sex or age category are statistically significant at the 5% level using the Wilcoxon rank sum test, due to small sample sizes with relatively large within-group variances. However, because our "sample" represents most of the adult population and because the sample reflects only one sickness episode for each person sampled, differences in

Table 1
Mean response for five measures of assistance given by others to each sick or injured Ache adult

Group	N	No. who gave[a]	No. Outside NF who gave[b]	Percent of givers outside NF[c]	No. food items received[d]	No. meat items received[e]	Median days sick[f]	Median days ago[g]
All	39	2.44	1.66	53.3	3.26	0.74	3.5	30
SE		0.30	0.32	6.8	0.39	0.17		
Min		1	0	0	1	0	0	0
Max		9	8	100	11	5	1,460	5,110
Male	22	2.82*	1.95	54.4	3.73*	0.77	4	23
SE		0.48	0.50	9.0	0.61	0.27		
Female	17	1.94*	1.29	52.0	2.65*	0.71	3	30
SE		0.29	0.35	10.6	0.38	0.19		
≤35 years	21	2.71	1.81	49.6	3.81	0.90	4	35
SE		0.50	0.53	9.2	0.64	0.27		
>35 years	18	2.11	1.47	57.8	2.61	0.56	3	16
SE		0.29	0.30	10.2	0.34	0.20		
Male ≤35	11	3.40*§	2.20	47.6	4.90†	1.20*	4	40
SE		0.93	0.99	13.0	1.19	0.49		
Male >35	6	2.33*	1.73	60.6	2.75	0.42	4	16
SE		0.40	0.41	12.7	0.37	0.26		
Female ≤35	10	3.09	1.45	51.5	2.82	0.64*	4	30
SE		0.41	0.51	13.6	0.44	0.24		
Female >35	12	1.67§	1.00	52.8	2.33†	0.83	3	15
		0.33	0.37	18.5	0.76	0.31		

[a] Total number of individuals from whom food was received during most recent down period.

[b] Total number of individuals from other nuclear families (NFs) from whom food was received during recent down period.

[c] Percent of all donors who were members of other NFs.

[d] Total number of food items reported given by other individuals during most recent down period.

[e] Total number of meat items reported given by other individuals during most recent down period.

[f] Number of days spent sick or injured during most recent down period.

[g] Number of days prior to interview when down period occurred.

*,‡$p < .10$ by Wilcoxon rank sum test.

†,§$p < .05$ by Wilcoxon rank sum test.

Note: Statistical significance is given only among pairs of means within the same grouping (sex, age, or sex/age). Significant pairs are denoted with the same symbol (e.g. *,‡,†, or §).

mean values can still be ecologically significant. Most importantly, men received more food from more individuals than did women, and younger men received the most food (and meat) from the highest number of people, while older women received the least amount of food (and meat) from the fewest number of people. This correlates with the relative status of age-sex groups on Ache reservations.

3.2. By individual sharing depth and production

Figure 1 shows the mean values for the response variables as a function of individual sharing intensity and production. Individuals who gave away a large percentage of their produc-

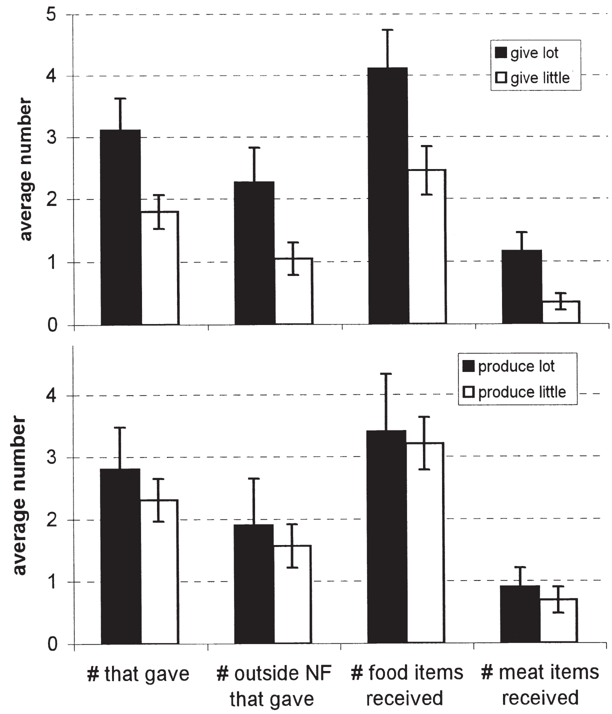

Fig. 1. Compensation to individuals based on individual generosity and production. Shown are the mean number (and standard errors) of total individuals who gave food, number of individuals outside the nuclear family (NF) who gave food, total number of food items received, and total number of meat items received by a sick or injured individual who gave above ($n = 19$) or below ($n = 20$) the median proportion of their production away (top graph), or who produced above ($n = 10$) or below ($n = 29$) the top quartile amount of food (bottom graph).

tion received more food items (and more meat items) from more individuals (and from more individuals outside the nuclear family) when they were disabled than those who gave below the median level. Although similar trends may be predicted by production, the differences in magnitudes for high and low producers are small. As predicted, both *philanthropic* and *means-well* individuals received higher levels of compensation than *greedy* and *ne'er-do-well* individuals across all measures, respectively (Figure 2) (see Prediction 1). There is little evidence for consistent bias favoring *philanthropic* over *means-well* individuals, while *ne'er-do-well* individuals received higher levels of compensation than *greedy* individuals across all measures (the opposite of Prediction 2), even though the average quantity of food *ne'er-do-well* individuals gave to others is significantly lower than that for *greedy* individuals (Table 2). Sample sizes among the four strategies given in Figure 2 are instructive because they reveal that of the 10 individuals who were high producers, 7 (or 70%) gave a large proportion away, whereas of the 29 individuals who were low producers, only 12 (or 41%) gave a large proportion away.

An obvious confounder with these results is duration of disability. In fact, duration of disability is significantly correlated with four of the five compensation measures (Pearson's $r = 0.58$,

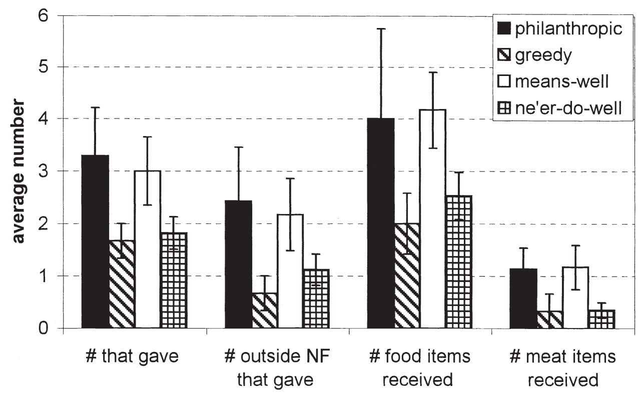

Fig. 2. Individual generosity and food production. Shown are the average returns during the most recent down period for *philanthropic* (generous high producers, $n = 7$), *means-well* (generous low producers, $n = 12$), *greedy* (stingy high producers, $n = 3$), and *ne'er-do-well* (stingy low producers, $n = 17$) individuals. NF = nuclear family.

0.55, 0.14, 0.55, and 0.65, respectively). The strength of these associations is due entirely to two outliers who (a) reported being sick for 2 months and 4 years, (b) reported receiving from nine individuals, and (c) were both classified as "shares a lot." To assess the impact of duration on generosity, we perform multiple linear regressions with both duration and percent of food production given to other nuclear families as predictors on each of the response variables. When duration is included in the regression, the magnitude of the beta coefficient for the "percent given to others" variable decreases by 0.43 donors, by 0.40 donors outside the nuclear family, 0.2% of donors being from another nuclear family, by 0.40 food items, and by 0.25 meat items.[2] Eliminating the two outliers from the sample decreases the mean difference in all response variables but does not eliminate the trend (nor significantly reduce their *p* values in the Wilcoxon rank sum test). We leave the two outliers in the sample because it is unclear how "stingy" individuals would have fared had they been sick for a similarly prolonged period of time.

The direction of causality assumed thus far is that generosity leads to compensation when disabled, but there exists the possibility that people may become generous because they have expectations of future disability. Because the estimates of generosity are based on sharing behavior over the entire sample period, while sickness events occurred throughout and prior to the sample period, we cannot rule out the possibility of this reverse causality. Although "shares a lot" individuals were disabled for a median of 5 days while "shares little" individuals were sick for a median of 4 days, there appears to be no significant increase or decrease in the percentage kept in the nuclear family before and after sickness episodes among those who were sick during the sample period.

3.3. Generosity?

It is unclear whether "shares a large proportion of their individual production" (as defined in the model) is a valid proxy for signaling the kind of reputation for generosity that yields

[2] Although it is not appropriate to use linear regression on non-normally distributed data, it suffices for illustrating the point that duration as a predictor variable does not eliminate the significant effect of generosity.

Table 2
Mean percent (and standard error) kept by the individual acquirer and absolute amounts (in kg) given to other individuals

	Gives	
	Lot	Little
Produces		
Lot	4.8%	15.2%
	(1.9%)	(1.6%)
	68.8 kg	42.8 kg
	(19.4 kg)	(17.7 kg)
Little	5.5%	31.0%
	(1.3%)	(5.1%)
	10.1 kg	3.8 kg
	(3.0 kg)	(0.8 kg)

Gives/produces lot is *philanthropic*, gives little/produces lot is *greedy*, gives lot/produces little is *means-well*, and gives/produces little is *ne'er-do-well* strategy.

benefits when disabled. Future work with the Ache will investigate emic definitions of generosity, but for current exploratory purposes, we create three additional measures that capture other aspects of generosity associated with food sharing: (1) the nuclear family shares a large proportion of their total production; (2) the nuclear family gives to many other nuclear families over the entire sample period; and (3) the nuclear family gives on average to a large number of nuclear families *per distribution.* "Generous" and "stingy" nuclear families are those that ranked above or below the median for each of these measures.

Figure 3 gives the means (and standard errors) for the compensation measures as a function of each of the generosity variables. Residence in a nuclear family that shared a large proportion of its production (median = 50%) seems to have a smaller positive impact on receiving aid than does having shared a large proportion of your own individual production, although the percentage of donors outside the nuclear family is significantly higher (Table 3). Giving to a greater average number of nuclear families per distribution (median = 2) also seemed to have a larger positive impact than does having given to a greater total number of nuclear families (median = 13) over the entire sample period (Figure 3). This suggests that consistency may be worth more in terms of compensatory benefits than breadth of sharing. Moreover, Figure 4 shows that those who gave a large percentage of family production to a high (above the median) number of other nuclear families per distribution received from a higher number of donors (total and those outside nuclear family) and received more food than those who gave to few other nuclear families (whether they gave a large or small percentage of their production to those families).

Table 3 lists the group comparisons from the analyses that were statistically significant at the 5% or 10% level using the Wilcoxon rank sum test.

4. Discussion and conclusion

We have argued that long-term payoffs may be sufficient to compensate for the short-term costs of extravagant food sharing behavior not easily explicable by other models. The long-

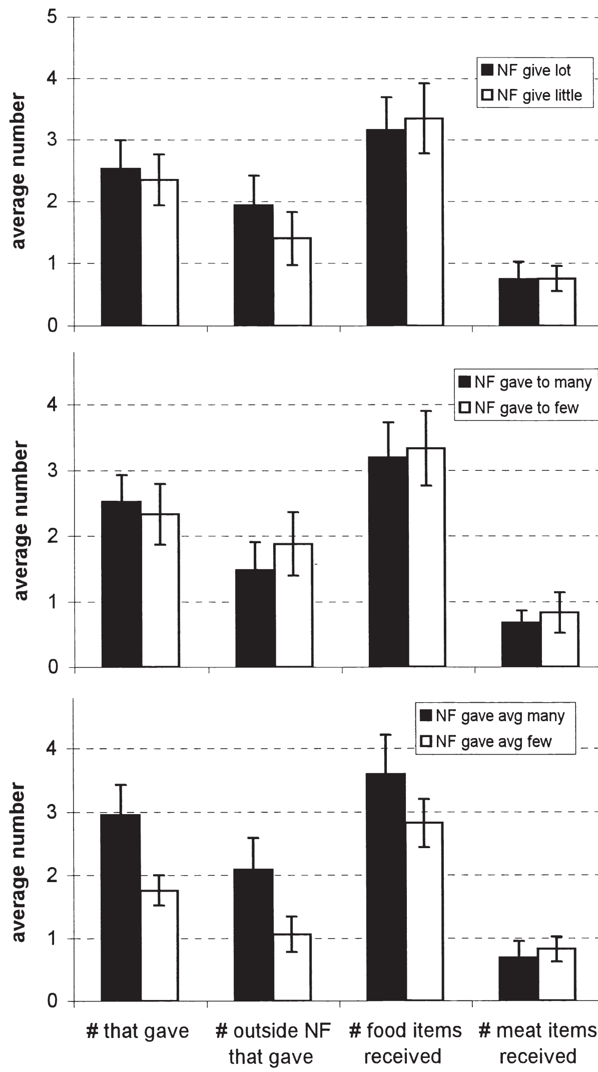

Fig. 3. Nuclear family (NF)-based generosity measures and compensation. Shown are compensation measures during sickness episodes for those individuals living in NFs that gave above ($n = 19$) or below ($n = 20$) the median proportion of food to other NFs (top graph), gave above ($n = 21$) or below ($n = 18$) the median total number of NFs over the entire sample period (middle graph), and gave on average to an above ($n = 22$) or below ($n = 17$) median number of NFs per distribution (bottom graph).

term benefit proposed is food received during infrequent bouts of illness, accidents, and disease, when assistance is crucial and can have lasting impact on future survivorship and fertility. Individual sharing patterns (proportion shared) and, to a lesser extent, nuclear family sharing patterns (average number of families shared with per distribution) are significant predictors of the number of donors and overall amount of food received by individuals during disabled periods. There is less evidence that high production alone yields significant payback

Table 3
Summary of statistically significant effects

Group 1	Group 2	No. that gave	No. outside NF that gave	Percent of givers outside NF	No. food items received	No. meat items received
Male	Female	* (>)			* (>)	
Male <35	Male >35	* (>)				
Male <35	Female >35	† (>)			† (>)	
Gives lot	Gives little	† (>)	* (>)		† (>)	† (>)
Philanthropic	*Greedy*	† (>)	† (>)	* (>)	* (>)	* (>)
Means-well	*Ne'er-do-well*	† (>)	† (>)		† (>)	† (>)
Means-well	*Greedy*	† (>)	† (>)	* (>)	† (>)	* (>)
NF gave avg many	NF gave avg few	† (>)	* (>)			
NF gives lot and to avg many	NF gives lot to avg few	* (>)				
NF gives little and to avg many	NF gives little to avg few	* (>)	** (>)			

(>) shows that mean response in Group 1 is statistically greater than that in Group 2.
*$p < .10$ by Wilcoxon rank sum test.
†$p < .05$ by Wilcoxon rank sum test.
NF = nuclear family.

during periods of illness or injury. Furthermore, that *greedy* individuals gave more absolute quantities of food to others than did *means-well* individuals (Table 2), but still received less assistance from others when disabled (Figure 2 and Table 3), suggests that "fairness" based on relative generosity (i.e., total given divided by total produced) was a salient influence on others' motivation to offer aid during times of need. This finding is in contrast to the main prediction by Sugiyama and Chacon (2000) that the "best" hunters will be the ones most likely to receive aid during down periods, but consistent with their notion that the "loyal deputy, not particularly skilled, but eminently dependable" is valued and thus rewarded as well. Like Hawkes in her discussion of the showing-off hypothesis, Sugiyama and Chacon (2000) attempt to explain why some individuals might hunt while assuming that the distribution of all hunted food is a given. Under this scenario, all hunters are equally generous in relative terms, but not in terms of absolute amounts given. Our model is similar to the showing-off model in its attempt to explain display behavior motivated by the pursuit of status (or avoidance of bad reputations), but differs from the showing-off model in several fundamental ways. The model in this paper (and in Sugiyama and Chacon, 2000), focuses attention on the long-term benefit due to assistance during disabled periods, rather than increased social attention or mating benefits in general. More importantly, it is argued that individuals can manipulate their generosity, rather than assuming that acquirers have no control over distributions and that food is shared only because of tolerated theft. Finally, this model avoids the second-order collective action problem of the showing-off model.

It is important to note that this paper focuses only on the return of food items during disabled periods, although other unmeasured currencies of compensation may be equally or more important. For example, other individuals caring for and feeding the offspring of an injured or sick

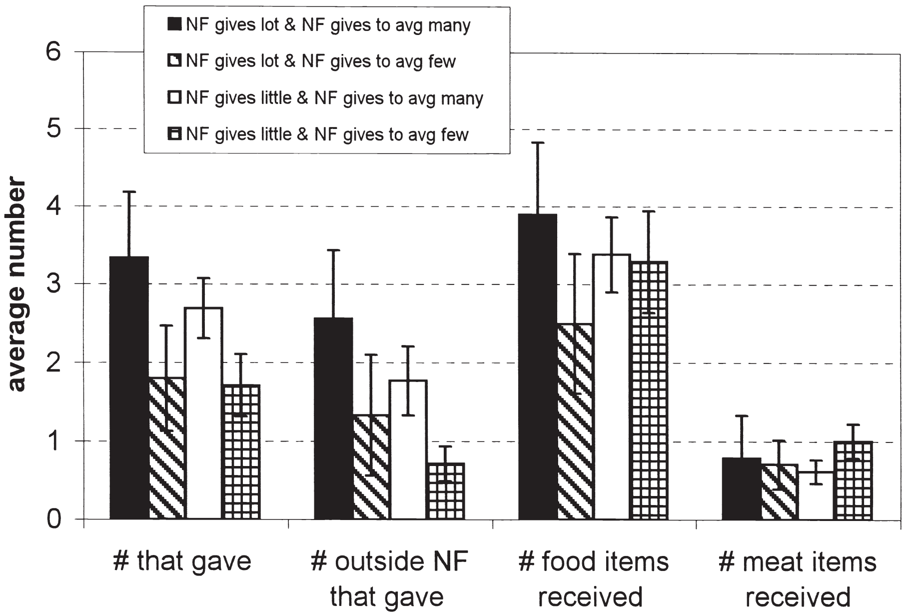

Fig. 4. Compensation based on nuclear family (NF) sharing breadth and depth. Shown are compensation measures for individuals living in NFs that gave either above or below the median proportion of food to other NFs *and* that gave on average to either an above or below median number of NFs per distribution ($n = 9$, 10, 13, and 7 for these four groups presented in the figure).

parent can have significant impacts on reducing child morbidity. Nonetheless, the results of this paper lend support to the idea that individuals who share a high proportion of their production to a wide audience are rewarded with more food from a broader spectrum of helpers during periods when they are unable to produce than those who share less. While the direction of the results is suggestive, it is not yet clear whether the benefits shown here are sufficient to compensate for the costs of altruistic food sharing. The data reflect only a single sickness event for each adult and alone cannot inform us about the "optimality" of altruistic behavior. Critical to understanding the adaptiveness of an *It's a Wonderful Life* reputation is estimating the costs of not sharing in terms of the long-term effects of brief episodes of decreased food intake during down periods. Therefore, tt is important to obtain better measures of the frequency and intensity of disabled periods for all adults and their offspring in study populations, as well as estimates of the marginal value of various macronutrients to injured and healthy individuals.

All generosity measures were operationalized as a function of median values for those measures, which implictly require sufficient variation to be meaningful (in the statistical sense and ecological sense, since lack of variation in any trait makes any signal of that trait uninformative). Variation in generosity can be maintained if one's level of generosity is a function of multiple factors, such as production ability, willingness to cooperate, personality traits, risk behavior, and proclivity toward sickness or accidents.

If altruistic behavior is analagous to paying a high premium for long-term health insurance, then extensive food sharing can be construed as risk-averse behavior in the long term, even if it may appear as risk-prone behavior in the short-term. We might expect that extensive food sharing is a condition-dependent strategy such that those with highest production are best able (or most willing) to pay the short-term costs of giving substantial portions of food away, whereas those with minimal production choose on average to consume larger proportions of their acquired food (and any food obtained from others) at the risk of foregoing the long-term benefits of sharing. Indeed, among the Ache, those who produce most are more likely to be categorized as "generous" than those who produce less. The fact that not all high producers are generous, however, implies that some individuals may favor short-term consumption benefits (due perhaps to larger family size or as a means of punishing those who produce little when production is a function of time investment) at the expense of long-term insurance, or that long-term insurance can perhaps be obtained through other means.

It is important to realize that the adaptiveness of an extensive food sharing strategy cannot be determined by examining only the costs and benefits associated with the mechanism proposed in this paper, because other long-term benefits such as delayed returns of food by others during times of no disability, greater clout in important group decisions, higher offspring survivorship due to the solicitude of others who have received food in the past, enhanced mating opportunities for self and offspring, and increased likelihood of exchange with those possessing valuable commodities also contribute to its long-term success as a strategy. Indeed, we suspect that the benefits of generosity may span a variety of payoffs from both reciprocal altruism and costly signaling (Boone, 1998; Smith and Bliege Bird, 2000; Gurven et al., 2000).

Future work should focus on the differential effects on reputation of alternative sharing behaviors and their associated payoffs within the context of individual tradeoffs between short and long term. For example, should a generous hunter always give away significant portions of his kills to maintain a reputation for being generous, or can he be more selective? Do others evaluate the long-term pattern of *i*'s sharing behavior with others in the population (or perhaps only with themselves), *i*'s most recent sharing history with others (or again only with themselves), or a weighted average of *i*'s sharing history assigning more weight to recent events? Understanding investment in reputation among "egalitarian" hunter-gatherers and small-scale horticulturists, where there is little inheritance of material wealth or social prestige and where none have overt priority of access to resources, may ultimately provide additional insight into the dynamics of "status" and "power" in more centralized and stratified contexts.

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Appendix

Recall the four strategies: *philanthropic* (produces and shares a lot), *means-well* (produces little but shares a lot), *greedy* (produces a lot but shares little), and *ne'er-do-well* (produces and shares little). Over a given time period, every individual produces either H or L and gives away to each of the other $N-1$ individuals an equal portion of the proportion they are willing to share. Over multiple time periods without any compensation, it is clear that *greedy* performs best (i.e., have the most amount of food), *means-well* performs worst, and *philanthropic* outperforms *ne'er-do-well* whenever the amount philanthropic can keep is higher, or $(1-s_g)H > (1-s_s)L$.

The next element of the model is to assign illnesses or injuries to individuals across time periods. We let each individual i in the population experience an illness or accident during time period t if $p_{i,t}$, derived from a uniform density distribution (1,10), is greater than some threshold value $1 \leqslant T \leqslant 10$. This means that every individual i in each time period t has on average a $T/10$ probability of experiencing an illness. This simple modeling approach assumes that illnesses are independently assigned to each individual for each time period. If disabled during period t, it is assumed that individual i produces nothing during this time period. Without a means of compensating the injured, all food that is given away by able-bodied individuals is given indiscriminately to all other individuals in the population.

The final element of the model is the compensation mechanism. This can be arranged such that only generous individuals reap rewards, or such that production has an interactive effect with generosity. This would mean that generous individuals who produce more receive more than generous individuals who produce less. However, in this model, each injured individual who has a reputation for generosity (i.e., shares s_g of production) receives additional compensation c during the time period when they are not producing from each able-bodied generous individual, and $c/2$ from able-bodied greedy individuals in the population. Total amounts given and received then are transformed to give the total utility or value of food, where value is an S-shaped function of amount. This transformation allows for large amounts of food received when sick to have higher utility than food consumed when healthy, thus capturing the ideas that aid during down periods contributes to long-term success, and that the costs to the donor are less than the benefits to the disabled recipient.

Simulation of the model

Simulations of the model were run by assigning fixed values to model parameters and comparing the total summed value achieved by the four strategists. The total value achieved at the end of 50 time periods averaged across 50 simulations in a population of 20 individuals (five of each strategy) is given for each strategy in Table A1 under different values of T and c, standardized to the highest performing strategy for each set of simulations. For all simulations, $H = 10$, $L = 5$, $s_g = 0.75$, and $s_s = 0.25$. Table A1 shows that if an individual is at 30% risk of being ill or injured ($T = 3$) over a given time period, the minimal compensation, $c = 1$, is sufficient to ensure maximal success for the generous strategies. For both 20% and

Table A1
It's a Wonderful Life model results ($N = 20$)

	Strategy			
Trial	Philanthropic	Greedy	Means-well	Ne'er-do-well
$T = 3, c = 1$	0.96	0.83	1.00	0.27
$T = 2, c = 2$	1.00	0.26	1.00	0.09
$T = 2, c = 1$	0.79	1.00	0.82	0.26
$T = 1, c = 2$	0.97	0.88	1.00	0.22
$T = 1, c = 1$	0.42	1.00	0.53	0.22

Final outcomes for each strategy are given as fractions of the highest performing strategy for each trial. *Philanthropic* strategists give away 75% of $H = 10$, *means-well* strategists give 75% of $L = 5$, *greedy* strategists give away 25% of $H = 10$, and *ne'er-do-well* strategists give away 25% of $L = 5$. $T/10$ is the probability that an individual experiences illness or injury during a time period; c = compensation given to a generous individual during down periods.

10% risk, the minimal compensation necessary to ensure highest gains for the philanthropic strategy is 2, or 40% and 20% of the production from low and high producers, respectively.

Although we assume in this model that most able-bodied individuals will automatically give food to injured generous individuals, it can be shown that *any* able-bodied individual should give c to each of n_h or n_l injured high or low producing individuals because they can personally benefit by receiving future shares when the injured individual recovers. This requires that $V(X/N - n_hc) + V[(X + n_hs_gH)/N] > 2V(X/N)$ for injured high producers and $V(X/N - n_lc) + V[(X + n_ls_gL)/N] > 2V(X/N)$ for injured low producers, where $V(\cdot)$ is the value function, and X is the total amount produced by all able-bodied individuals. Thus, help occurs when the value of receiving a portion n_hs_gH/N or n_ls_gL/N in the future outweighs the loss in value from giving n_hc or n_lc in the present. These inequalities give necessary but not sufficient cause for any *specific* individual to help, because some might expect to free-ride on the helping efforts of others. Deciding who should give back to generous individuals has been called the "second-order collective action problem," associated with Hawkes's showing-off model (Hill and Kaplan, 1993). When the marginal value of food donated by each helper to a sick individual is high (ensuring a quick recovery), the collective action problem disappears because per capita expected returns on the helping investment will be positive. Likeliness to give to disabled individuals also is bolstered when helping injured individuals also serves to maintain a reputation for generosity (especially because most of the additional benefits received are from other generous individuals in this model). An implication of these inequalities is that injured individuals are unlikely to receive any assistance when help does not significantly improve the injured individual's condition (as in the case of terminal illness), regardless of prior generosity displayed by the injured individual.

The purpose of this model is to demonstrate that a simple compensatory mechanism is sufficient to warrant the costs of reputation investment (i.e., sharing proportion s_g). The model assumes strong tolerated theft, so that everyone receives from everyone else's production during all time periods. However, any assortative sharing based on reputation would reduce the levels of compensation above and beyond normal food sharing practices necessary to enhance the long-term benefits of those who invest in reputation. Furthermore, if generous individuals of high productivity are rewarded more than those with low productivity (e.g., if $c_{low} = 0.75c_{high}$). this also decreases the threshold values making reputation for generosity more profitable.

The different strategists receive in time period t:

if $p_t > T/10$: <no illness>

$$philanthropic(t) = [(1-s_g)H - dc] + s_g H(n_{hh}-1)/(N-1) + s_s Hn_{hl}/(N-1) + s_g Ln_{lh}/(N-1) + s_s Ln_{ll}/(N-1)$$

$$means\text{-}well(t) = [(1-s_s)L - dc] + s_g Hn_{hh}/(N-1) + s_s Hn_{hl}/(N-1) + s_g L(n_{lh}-1)/(N-1) + s_s Ln_{ll}/(N-1)$$

$$greedy(t) = [(1-s_s)H - dc/2] + s_g Hn_{hh}/(N-1) + s_s H(n_{hl}-1)/(N-1) + s_g Ln_{lh}/(N-1) + s_s Ln_{ll}/(N-1)$$

$$ne'er\text{-}do\text{-}well(t) = (1-s_s)L + s_g Hn_{hh}/(N-1) + s_s Hn_{hl}/(N-1) + s_g Ln_{lh}/(N-1) + s_s L(n_{ll}-1)/(N-1)$$

or if $p_t \leqslant T/10$: <illness>

$$philanthropic(t) = dc + s_g H(n_{hh}-1)/(N-1) + s_s Hn_{hl}/(N-1) + s_g Ln_{lh}/(N-1) + s_s Ln_{ll}/(N-1)$$

$$means\text{-}well(t) = dc + s_g Hn_{hh}/(N-1) + s_s Hn_{hl}/(N-1) + s_g L(n_{lh}-1)/(N-1) + s_s Ln_{ll}/(N-1)$$

$$greedy(t) = s_g Hn_{hh}/(N-1) + s_s H(n_{hl}-1)/(N-1) + s_g Ln_{lh}/(N-1) + s_s Ln_{ll}/(N-1)$$

$$ne'er\text{-}do\text{-}well(t) = s_g Hn_{hh}/(N-1) + s_s Hn_{hl}/(N-1) + s_g Ln_{lh}/(N-1) + s_s L(n_{ll}-1)/(N-1)$$

where $n_{hh,}$ n_{hl}, n_{lh}, and n_{ll} are the numbers of able *philanthropic*, *means-well*, *greedy*, and *ne'er-do-well* individuals in the population and $N = 20$ is total group size. Individuals produce either a high ($H = 10$) or low ($L = 5$) amount of food each time period, and give either a generous proportion ($s_g = 0.75$) or stingy proportion ($s_s = 0.25$) away to other individuals. Every individual thus receives a portion of food from every other able individual during each time period. Each of d number of disabled *philanthropic* and *means-well* individuals in time period t additionally receives a compensation, c, from each able *philanthropic* and *means-well* individual. We let *greedy* individuals give only $c/2$ to each disabled generous individual, and *ne'er-do-well* individuals give nothing back to any of the disabled.

Absolute amounts obtained by each individual i at the end of each time period t were transformed to value by the function:

$$V_i(t) = 100/1 + 1499e^{-0.5 \times amount_i(t)}.$$

Total value in the final time period (50th) for each strategist was obtained by first summing the obtained value over all 50 periods, then averaging the final summed value across the five individuals with the same strategy. Numbers in Table A1 were calculated by standardizing each of the total values to the strategy with the highest final value.