ELSEVIER

Evolution and Human Behavior 33 (2012) 715 – 725

Evolution and Human Behavior

Original Article

The social cognition of social foraging: partner selection by underlying valuation☆

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Initial receipt 17 February 2012; final revision received 31 May 2012

Abstract

Humans and other animals have a variety of psychological abilities tailored to the demands of asocial foraging, that is, foraging without coordination or competition with other conspecifics. Human foraging, however, also includes a unique element: the creation of resource pooling systems. In this type of social foraging, people contribute when they have excess resources and receive provisioning when in need. Is this behavior produced by the same psychology as asocial foraging? If so, foraging partners should be judged by the same criteria used to judge asocial patches of resources: the net energetic benefits they provide. The logic of resource pooling speaks against this. Maintaining such a system requires the ability to judge others not on their short-term returns, but on the psychological variables that guide their behavior over the long term. We test this idea in a series of five studies using an implicit measure of categorization. Results showed that (a) others are judged by the costs they incur (a variable not relevant to asocial foraging), whereas (b) others are not judged by the benefits they provide when benefits provided are unrevealing of underlying psychological variables (despite this variable being relevant to asocial foraging). These results are suggestive of a complex psychology designed for both social and asocial foraging.
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Keywords: Social cognition; Cooperation; Sharing; Foraging; Evolutionary psychology

1. Introduction

Survival and reproduction require energy. To extract this energy, natural selection has given animals exquisitely crafted psychological mechanisms for foraging (for reviews, see Gallistel, 1990; Stephens, Brown, & Ydenberg, 2007). Humans are no exception: Experimental and ethnographic evidence reveals that the human mind also contains foraging specializations (Hill, Kaplan, Hawkes, & Hurtado, 1987; Silverman & Eals, 1992; Winterhalder & Smith, 2000; New, Krasnow, Truxaw, & Gaulin, 2007; Hutchinson, Wilke, & Todd, 2008; Wilke & Barrett, 2009; Pacheco-Cobos, Rosetti, Cuatianquiz, & Hudson, 2010; Krasnow et al., 2011). Although much of the experimental work on humans has addressed asocial, solitary foraging, an emerging literature has begun experimentally investigating human social foraging (e.g., Kameda, Takezawa, Tindale, & Smith, 2002; Kameda & Nakanishi, 2003; Kameda & Tamura, 2007; King et al., 2011; Hills & Pachur, 2012; Kaplan, Schniter, Smith, & Wilson, 2012). Although some aspects of human social foraging are similar to other animals', anthropological work shows that humans also have a unique style of social foraging: resource pooling (e.g., Kaplan & Hill, 1985; Cashdan, 1992; Fiske, 1992; Gurven, Allen-Arave, Hill, & Hurtado, 2000; Kaplan, Hill, Lancaster, & Hurtado, 2000; Gurven, 2004). Here, we use an experimental approach to study some of the cognitive mechanisms that give rise to this ability.

1.1. Foraging and social foraging

Successful foraging requires engaging with a complex world. Consider the psychological requirements of foraging in patchy environments. In such environments, prey items (e.g., fruit, insects, mammals) are distributed in patches—

☆ This research was supported by an NIH Director's Pioneer Award to Leda Cosmides and NSF grant 0951597 to Leda Cosmides and John Tooby.

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http://dx.doi.org/10.1016/j.evolhumbehav.2012.05.007

clumped together rather than randomly distributed. The marginal value theorem (Charnov, 1976) describes optimal foraging in these environments, predicting how long an animal should stay in a patch before leaving. Foraging mechanisms that embody the constraints of the marginal value theorem must estimate (a) the time to travel between patches, (b) the energy cost during travel, (c) the time to search for prey within a patch, (d) the energy cost of searching, (e) the number or amount of prey encountered over time in a patch (which is likely to change as the patch becomes depleted), and (f) the energetic return of consuming prey. Many of these variables will differ for different prey. More generally, optimal foraging requires estimating energetic return rates and implementing adaptive behavior in the face of changing external and internal environments (Gallistel, 1990; Stephens et al., 2007).

As with many foraging models, the marginal value theorem describes asocial foraging—foraging conducted without coordination or competition with other conspecifics. Other models have been developed that examine social aspects of foraging (for a review, see Giraldeau & Caraco, 2000). For instance, research has examined how animals in competition distribute themselves among foraging patches (e.g., Harper, 1982), how animals maintain collective vigilance for predators (e.g., Clutton-Brock et al., 1999), and how animals alert others to patches (e.g., Chapman & Lefebrve, 1990). This work reveals how sociality alters foraging dynamics in important ways.

Humans engage in a unique type of social foraging: multiple people forage and pool the resources they acquire. Co-foragers are not necessarily close kin and do not necessarily travel together during foraging trips. This type of foraging has variously been called resource pooling, communal sharing, social sharing, and risk reduction, among other terms (see above citations). The advantage of this system is that it buffers against shortfalls. Foraging is often high variance: On a given day, bad luck can prevent a forager from acquiring food. Even worse, injury and illness can prevent a person from foraging for extended periods—sometimes long enough that a forager would likely die without provisioning by others (Sugiyama, 2004). When foragers are successful, however, they may acquire more food than they can usefully consume before it spoils. They can share this excess with unsuccessful foragers, thereby providing a large benefit to others at a small personal cost. With frequent role reversals, most foragers will sometimes be successful and sometimes fail. Thus, resource pooling is not a unilateral flow of resources, but a type of social insurance that on average and over the long term can benefit those involved (Kameda, Takezawa, & Hastie, 2003). [Of course, in any given instance, a particular person or family might not earn a net benefit by participating. Moreover, exchanges do not need to be of equal magnitude: Highly productive people might give away more than they ever receive, but nonetheless benefit from provisioning in times of extreme need (Gurven et al., 2000).]

Could this system be implemented by the same variables that implement asocial foraging? This would be consistent with social exchange approaches to partner choice. These approaches hypothesize that the mind judges interaction partners by the rewards partners provide and the costs they inflict on the self (Homans, 1958, 1966; Thibaut & Kelley, 1959; Gouldner, 1960; Moreland, Levine, & Cini, 1993; Cropanzano & Mitchell, 2005). Although these are clearly important variables and this approach has generated an impressive body of supportive data, tracking only personally received benefits and personally incurred costs may not be sufficient to maintain resource pooling. Consider what would happen if humans judged foraging partners by the same metric used to judge a typical asocial foraging patch—return rate. If a foraging partner was unable to contribute due to bad luck, illness, or injury, then interacting with them would provide a low return rate. This, in turn, would lead to them being rejected as a foraging partner. Indeed, because almost everyone will be the victim of bad luck, illness, or injury, most people in one's social world would—by a return rate criterion—gradually be excluded as foraging partners. Ultimately, this causes the breakdown of a resource pooling system. To sustain such a sharing system, the mind must have a way to "see through" overt return rates and use other metrics (see also Delton, Cosmides, Guemo, Robertson, & Tooby, 2012). These other metrics must allow the mind to discover those individuals who will be valuable sharing partners over the long term, in the face of extensive variability.

In other words, this is a question of ecological rationality (Gigerenzer, Todd, & the ABC Research Group, 1999). What kinds of psychological variables and computations are necessary to behave adaptively in the context of resource pooling? In an ecological rationality approach, the computations performed and the information required depend critically on the problem being solved. Although personal benefits and personal costs might allow adaptive behavior in some contexts (e.g., asocial foraging), they are unlikely to support adaptive behavior in resource pooling; other variables are needed.

One possible solution is for the mind to estimate the underlying psychological variables that guide a foraging partner's behavior. These variables would more usefully predict behavior over the long term than overt return rate. Return rate, while useful for asocial resource patches, conflates several distinct causes of a person's contribution level, causes that may dissociate over the long term. Such causes include features of the person (such as willingness or ability to contribute) and features of the situation (such as injury or luck) that might hinder or enable successful contribution. Variables that conflate several distinct features of the world often make poor guides for behavior (Gallistel & King, 2009). Conversely and by definition, estimates of the psychological variables that underlie another person's behavior are estimates of a single, causal feature of the world. What might such internal variables look like?

1.2. A psychological variable for social decision making: welfare tradeoff ratios

Members of a social species often make tradeoffs between their own welfare and the welfare of others. Do you watch your friend's children while they forage or tend your own garden? Do you wash the dishes or watch television and leave the dishes for your spouse? Do you donate a kidney to a relative or forgo the risk? Recent work suggests that welfare tradeoffs are regulated by a series of quantitative psychological variables called *welfare tradeoff ratios* (Lieberman, Tooby, & Cosmides, 2007; Tooby, Cosmides, Sell, Lieberman, & Sznycer, 2008; Sell, Tooby, & Cosmides, 2009; Delton, 2010; Sell, 2011). As a simplified heuristic, welfare tradeoff ratio theory proposes that an organism should increase another's welfare at a personal expense when the ratio between self's and other's welfare surpasses a threshold—that is, surpasses a welfare tradeoff ratio (WTR). Mathematically, increase the other's welfare when $WTR_{other} > Cost_{self} / Benefits_{other}$. Greater welfare tradeoff ratios imply greater valuation of the other. The larger goal of this theory is to begin formalizing what it means for someone to be a good reciprocity partner or cooperative forager—to begin breaking down these intuitive notions into the underlying variables and concepts they are composed of (Lim, 2012). Welfare tradeoff ratios are hypothesized to be one element among many that generate our social intuitions.

Over the short term, resource pooling is a welfare tradeoff: You must decide whether to provide a benefit (e.g., food) to others at a personal cost (e.g., forgone consumption and/or the effort required to produce). Thus, your mind must generate and consult the welfare tradeoff ratio relevant to the resource pooling system. Importantly, because this is also true of other members of your group, you could also estimate the welfare tradeoff ratios that regulate their behavior.

To see this, note how welfare tradeoff ratios are used: If I can provide my group a benefit $Benefit_{group}$ at personal cost $Cost_{me}$, I will actually do so only if $WTR_{group} > Cost_{me} / Benefit_{group}$. That is, the group will receive the benefit when my welfare tradeoff ratio for the group—my valuation of the group—is greater than the cost–benefit ratio. All else being equal, as my costs increase, your (lower bound) estimate of my WTR should increase. This leads to the first prediction we test: Individuals willing to sacrifice more personal welfare will be inferred to have a higher WTR toward the group (see also Barclay, 2004; Barclay & Willer, 2007; Cottrell, Neuberg, & Li, 2007). Although predicted by a welfare tradeoff approach to resource pooling, this prediction is not consistent with an asocial optimal foraging approach. The latter approach would only examine *personal* costs and benefits; *others*' costs are irrelevant. After all, foragers do not concern themselves with the energy a tree requires to produce fruit, only with how valuable the fruit is and how costly it is to obtain.

The equation relating welfare tradeoff ratios to costs and benefits suggests an additional hypothesis: As $Benefit_{group}$ increases, the entire fraction becomes smaller, implying that *smaller* benefits should be linked with *larger* inferred (lower bound) estimates of WTRs. Indeed, in other work, the size of the benefits does matter in inferences about welfare tradeoff ratios (Sell, 2005). Instead of testing this again, however, we use variations in benefits to further separate welfare tradeoff theory from an asocial optimal foraging approach. According to welfare tradeoff theory, benefits and costs are only inferentially powerful when they reveal underlying psychological variables. Benefits and costs can only be revealing if they actually enter into the decision process. If benefit size does not enter into decisions, then variations in benefits should be weakly or not at all related to social perceptions. Variations in benefits could be unrevealing if benefit size cannot be known until after a decision has been made and action taken. This is the second prediction we test: When variations in benefits delivered are unrevealing, they will play little or no role in inferences about welfare tradeoff ratios. This is not predicted from an asocial foraging approach. On this latter view, benefit size is a key variable, regardless of how or why the benefits were produced. After all, a forager comparing two fruit trees would form a preference based on which produced more fruit; this preference would not be mitigated if it turned out one tree was lucky enough to have grown over a rich water supply.

1.3. The present research

In sum, our analysis makes two predictions about benefits and costs in social foraging:

1. The mind should encode differences in costs willingly incurred in the course of provisioning a resource pooling system. People who incur relatively large costs should be seen as highly valuing the group and preferred as group members. This was tested in Studies 1–3.
2. The mind should not encode, or perhaps weakly encode, differences in benefits provided by others, insofar as those variations are unrevealing of underlying psychological variables. This was tested in Studies 4 and 5.

These predictions are opposite those of an asocial foraging approach. On the latter approach, the mind should track benefits received by the self and ignore the costs others incur. To be clear, asocial foraging mechanisms are surely a part of the human mind. Our argument is that these mechanisms alone cannot support resource pooling; other mechanisms are necessary. Our experiments use contexts designed to highlight these additional social variables. The confirmation of our predictions would be especially striking given past work on the impact of benefits provided and costs incurred in person perception (Tesser, Gatewood, & Driver, 1968; Greenberg, Block, & Silverman, 1971). Opposite our predictions, this work found that benefits tended to have a greater influence than costs on perceptions. The context of

this work, however, did not involve resource pooling, and the stimuli were often arranged such that benefits, but not costs, were more revealing of underlying variables.

To see whether the mind distinguishes between individuals who pay small or large costs or between individuals who provide large or small benefits as part of a resource pooling system, we used an implicit categorization measure (Taylor, Fiske, Etcoff, & Ruderman, 1978). Although welfare tradeoff ratios are conceptualized as continuous magnitudes, evidence suggests that humans can flexibly turn dimensional distinctions into categorical distinctions (Jackendoff, 1983; Hampton, 2007). Thus, a categorical measure can still be used to probe an underlying continuous dimension. A primary benefit of the categorization measure is that is allows us to see how subjects spontaneously view this social world. There are no explicit instructions to be vigilant for distinct types of people, and the task itself does not require any explicit sorting or categorization. Instead, subjects complete an apparent memory test—a common occurrence in a psychology laboratory. Thus, any observed categorization will be generated by the subjects' themselves. Research over 30 years has used this method to investigate a wide variety of social categories and dimensions (for a review, see Klauer & Wegener, 1998), including race, coalition affiliation, sex, age, status, kinship, and moral standing, among others (Taylor et al., 1978; Fiske, Haslam, & Fiske, 1991; Stangor, Lynch, Duan, & Glass, 1992; Kurzban, Tooby, & Cosmides, 2001; Sherman, Castelli, & Hamilton, 2002; Lieberman, Oum, & Kurzban, 2008; Cimino & Delton, 2010; Delton et al., 2012).

Nonetheless, although the categorization measure reveals whether the mind makes certain distinctions, it does not directly reveal the content of the categories. Therefore, after the categorization task, subjects completed a number of rating scales. These measured whether the categories were associated with the social consequences predicted by welfare tradeoff theory. Key among these were questions that assessed whether targets were perceived as highly valuing the group and questions that assessed whether targets were preferred as group members.

2. Study 1: variations in cost incurred

We designed Study 1 to test the predictions that (a) differences in costs incurred will lead to categorization and that (b) those individuals who incur greater costs will be seen as more highly valuing the group and will be preferred as partners. These predictions follow from a welfare tradeoff ratio approach to resource pooling but not from an asocial foraging approach.

2.1. Methods

2.1.1. Subjects

Fifty-eight students (33 female) at the University of California, Santa Barbara (UCSB) participated in exchange for partial course credit.

2.1.2. Procedure and dependent variables

The entire experiment was computerized, and subjects worked independently in semiprivate cubicles. The methods were modeled on those of Delton et al. (2012). To establish a resource pooling scenario, subjects learned about a fictitious group of people who were traveling on a plane. The plane had crashed on a deserted island, thereby stranding the passengers. Some people were injured in the crash, and everyone was hungry. Everyone who was not injured agreed to go out individually and forage for food. They agreed that all food they found would be brought back and shared with the group.

Subjects were asked to form impressions of eight of these individuals (the "targets," each represented by a facial photograph of a white man; see Delton et al. (2012) for prerating details). For each of 5 "days" on the island, subjects read a sentence describing each target's foraging experience, paired with that person's photograph (40 total sentence–photo pairs; see the Supplemental Figures, available on the journal's website at www.ehbonline.org, for screenshots). Sentence–photo pairs were each presented for 10 s. On 3 days, each target found and shared a resource by paying a default cost (i.e., the time and energy necessary to walk and look for food); because these sentences do not discriminate between targets, we call them *nondiagnostic sentences*. For example, "With some passion fruit in hand, he walked over a few fallen logs and went back to camp." On 2 additional days, half of the targets chose to pay an exceptionally large cost to forage, and the other half paid a small, accidental cost; because these do discriminate, we call them *diagnostic sentences*. For example, "In order to catch some crabs, he waded into the shark-infested shallows off the bay" versus "While picking strawberries, he cracked and broke his watch against a rock." Note that all targets contributed food to the group on all instances; despite varying in costs incurred, their contributions were equated. Specifically, across sentences, targets each contributed fruits twice, animal products twice, and vegetables once. The pairings of high- or low-cost sentences with a given photograph and the order of the targets within each day were randomly determined for each subject. The order of sentences was randomly determined for each subject with the constraints that all targets were paired with a nondiagnostic sentence on the first day and no target was paired with a diagnostic sentence 2 days in a row.

After viewing the 5 foraging days, subjects completed a surprise memory test requiring them to match each event to the target who originally performed it. The computer displayed all eight photos simultaneously and displayed each sentence one by one (see Supplemental Figures, available on the journal's website at www.ehbonline.org). Each sentence remained on the screen until the subject responded by selecting a photo. Categorization was assessed using the memory confusion protocol of Taylor et al. (1978). In this protocol, the pattern of errors made by subjects in the

surprise memory test is used to infer social categorization. (Correct responses are not analyzed because it is impossible to know if they are due to accurate memory, a memory confusion, or random responding.) If subjects make more within- than between-category confusions, this suggests that the hypothesized categories are psychologically real to them. Within-category confusions occur when a subject misattributes an action by (e.g.) an individual who paid a large cost to another individual who paid a large cost. Between-category confusions occur when a subject misattributes an action by (e.g.) an individual who paid a large cost to an individual who paid a small cost. We compute a *categorization score* by subtracting between-category confusions from within-category confusions (after correcting for differing base rates by multiplying between-category confusions by ¾; without such a correction, random responding would appear as systematic misattribution to the opposite category). If categorization is occurring, categorization scores should be greater than zero. Based on previous work (Delton et al., 2012), we expect categorization scores for the diagnostic sentences to show the strongest, most consistent evidence of categorization, with comparatively weaker effects for the nondiagnostic sentences. Thus, although we report results for both types of sentences, our interpretations are based only on results for the diagnostic sentences.

After completing the categorization measures, subjects rated the targets on a number of dimensions using 7-point scales with appropriate anchors at "1" and "7." Brief descriptions are displayed in Tables 1 and 2. For instance, subjects rated how altruistic targets appeared to feel toward the group, how much targets appeared to care about the group, and how desirable the targets were as group members. At no point during the memory test or the impression ratings did we provide subjects with information about targets' behavior; only photographs were available.

2.2. Results

We examined each measure across all five studies for sex differences with a two-tailed α of .001 (slightly less conservative than a Bonferroni correction for a total α of .05). No differences passed this threshold. Sex differences do not appear to qualify the results.

All p values are two-tailed, and Pearson r is used as a measure of effect size (Rosenthal, Rosnow, & Rubin, 2000).

2.2.1. Are people paying large versus small costs categorized separately?

Yes. Subjects categorized targets based on the costs targets incurred while foraging: Categorization scores for the diagnostic sentences were reliably greater than zero, mean ±S.D.=2.73±3.50, t_{57}=5.94, p<.0001, r=.62. Categorization scores for the nondiagnostic sentences were not different from zero, mean±S.D.=0.78±3.85, t_{57}=1.54, p=.13, r=.20.

2.2.2. Are people paying large costs viewed more positively?

Yes. Subjects viewed targets who incurred larger costs more positively on all items, all ps<.07 and all rs≥.24

Table 1
Effect sizes (r) of mean differences on the impression items

Item	Study 1	Study 2	Study 3	Study 4	Study 5
	Benefiting group at large cost always viewed more positively			Providing large benefits always viewed more positively	
Feels altruistic toward group	.36**	.40**	.42***	.22	.08
Cares about group	.58***	.14	.50***	.15	.18
Desirable as a group member	.60***	.41**	.49***	.03	.25†
Desirable for 1:1 cooperation	–	.45***	.50***	.30†	.28*
Willing to contribute	–	.46***	.48***	.10	.28*
Trustworthy	.45***	.32*	.54***	.09	.26*
Deserves respect	.48***	.43***	.49***	.19	.28*
Likable	.49***	.18	.45***	.32*	.14
Put in effort	.59***	.54***	.52***	.07	.24†
Competent	.61***	.46***	.49***	.21	.19
Is not selfish	.24†	–	–	–	–
Intended to pay large cost	.48***	–	–	–	–
Worthy of being leader	.57***	–	–	–	–
Does not deserve punishment	.29*	–	–	–	–
Deserves reward	.50***	–	–	–	–

Note. Each effect size, r, represents the comparison of two means: one mean from targets who pay a large cost and one from targets who pay a small cost (Studies 1–3) or one mean from targets who provide a large benefit and one from targets who provide a small benefit (Studies 4 and 5). Comparisons were made using repeated-measures t tests. Interested readers can convert using $r=\text{sqrt}(t^2/(t^2+df))$; $t=(r^2*df)/(1-r^2)$; df=sample size minus 1. "–" indicates that data on this item were not collected in a particular study.

† p<.10.
* p<.05.
** p<.01.
*** p<.001.

Table 2
Means (standard deviations) of impression items

Item	Study 1		Study 2		Study 3		Study 4		Study 5	
	High cost	Low cost	High cost	Low cost	High cost on behalf of group	Low cost on behalf of group	Large benefits	Small benefits	Large benefits	Small benefits
Feels altruistic toward group	4.78 (0.94)	4.48 (1.03)	4.92 (0.86)	4.60 (0.90)	4.70 (1.22)	4.13 (1.16)	5.02 (1.27)	4.84 (1.29)	4.56 (1.17)	4.46 (0.98)
Cares about group	5.29 (0.84)	4.75 (1.00)	5.13 (0.96)	5.01 (0.93)	5.23 (0.92)	4.51 (1.09)	5.41 (0.92)	5.29 (0.99)	5.17 (1.17)	4.96 (1.15)
Desirable as a group member	5.38 (0.93)	4.63 (1.20)	5.14 (0.94)	4.77 (0.94)	4.99 (1.05)	4.36 (0.94)	5.07 (1.12)	5.03 (0.80)	4.75 (1.17)	4.49 (1.04)
Desirable for 1:1 cooperation	–	–	4.94 (1.02)	4.49 (0.98)	4.60 (1.09)	3.89 (1.05)	4.98 (1.11)	4.66 (1.03)	4.32 (1.16)	4.05 (1.08)
Willing to contribute	–	–	5.57 (0.88)	5.14 (0.93)	5.24 (0.84)	4.63 (1.05)	5.51 (0.95)	5.41 (0.89)	5.07 (1.03)	4.81 (1.08)
Trustworthy	5.19 (0.86)	4.73 (1.08)	5.12 (0.94)	4.86 (0.98)	4.87 (0.91)	4.23 (0.95)	5.01 (0.96)	4.91 (0.80)	4.73 (1.13)	4.46 (1.07)
Deserves respect	5.09 (0.91)	4.56 (1.05)	5.23 (0.94)	4.78 (0.95)	4.93 (0.78)	4.33 (0.84)	5.16 (0.94)	4.99 (1.07)	4.67 (0.92)	4.39 (0.95)
Likable	5.04 (0.82)	4.56 (1.07)	4.92 (0.95)	4.76 (0.98)	4.81 (0.81)	4.24 (0.89)	5.03 (0.96)	4.70 (0.86)	4.43 (0.96)	4.31 (0.92)
Put in effort	5.45 (0.85)	4.73 (1.03)	5.54 (0.85)	4.99 (0.86)	5.24 (0.89)	4.54 (0.95)	5.40 (1.03)	5.33 (0.98)	5.04 (1.02)	4.80 (1.02)
Competent	5.41 (0.82)	4.78 (1.06)	5.26 (0.97)	4.82 (0.88)	5.15 (0.99)	4.63 (1.02)	5.29 (0.97)	5.12 (0.90)	4.77 (1.07)	4.58 (1.06)
Selfish	2.72 (1.13)	2.95 (1.06)	–	–	–	–	–	–	–	–
Intended to pay large cost	4.39 (1.18)	3.78 (1.20)	–	–	–	–	–	–	–	–
Worthy of being leader	4.75 (1.07)	3.91 (1.35)	–	–	–	–	–	–	–	–
Deserves punishment	2.16 (1.07)	2.43 (1.20)	–	–	–	–	–	–	–	–
Deserves reward	5.36 (0.99)	4.77 (1.27)	–	–	–	–	–	–	–	–

Note. "–" indicates that data on this item were not collected in a particular study.

(Tables 1 and 2). Importantly, subjects viewed targets who incurred large costs, relative to those incurring small costs, as feeling more altruistic toward the group (r=.36) and as being more desirable as a group member (r=.60).

Across both types of measures in Study 1, the results were consistent with a welfare tradeoff approach to resource pooling, which predicts that others' costs incurred should be encoded and used for partner selection. The results were not consistent with an asocial optimal foraging approach, which predicts that others' costs should play little role.

3. Study 2: varying costs with constant intentions

Study 1 is consistent with the hypothesis that larger incurred costs lead to greater estimated welfare tradeoff ratios. However, there is a potential confound in the stimuli: All targets necessarily paid the default costs of foraging, but only those who paid a large cost paid any additional cost intentionally; those who incurred a small cost did so accidentally. Could the effects in Study 1 have been driven by whether an additional cost was paid intentionally, instead of the size of the cost? To rule out this alternative explanation, Study 2 replicated the first study but removed sentences involving incidental costs. Thus, half the targets paid an exceptional cost on some occasions in addition to the default costs of foraging; the other half only paid the default costs. In all cases, all costs were paid intentionally.

3.1. Method

Fifty-nine students (31 female) at UCSB participated. The procedure was identical to Study 1 except that all sentences with small incidental costs were removed. This required having only 4 days of foraging such that there was no initial day during which only nondiagnostic sentences were shown. Note that only targets who paid large costs were paired with diagnostic sentences. We added two new questions to more directly assess the value of targets as cooperation partners. We also reduced the total length of the rating portion by removing a number of peripheral questions.

3.2. Results

3.2.1. Are people paying large versus small costs categorized separately?

Yes. Subjects categorized targets based on the costs they incurred while foraging: Categorization scores for the diagnostic sentences, which in this study only existed for people paying large costs, were reliably greater than zero, mean±S.D.=1.38±2.82, t_{58}=3.75, p<.001, r=.44. Categorization scores for the nondiagnostic sentences were not different from zero, mean±S.D.=−0.39±3.65, t_{58}=−0.81, p=.21, r=−.11.

3.2.2. Are people paying large costs viewed more positively?

Yes. Subjects viewed targets who incurred larger costs more positively on all but two items; for the remaining eight items, ps<.05 and rs≥.30 (Tables 1 and 2). Importantly, subjects viewed targets who incurred large costs, relative to those incurring small costs, as feeling more altruistic toward the group (r=.40) and as being more desirable as a group member (r=.41). Despite being in the predicted direction, however, the effects for likability and caring about the group were small and not significant.

4. Study 3: manipulating the target of costs incurred

In Studies 1 and 2, subjects consistently perceived targets paying larger costs as more competent. Is a perceived

difference in ability to contribute—not a perceived difference in willingness—driving our results? To test against this, in Study 3, half the targets incurred an exceptional cost to benefit the group, and the other half benefited the group at the default cost and then incurred an exceptional cost to benefit themselves. This equates ability to incur costs. Indeed, the latter targets actually found more food and are arguably objectively more able.

The hypothesis that greater costs incurred lead to higher inferred welfare tradeoff ratios assumes that the mind is attempting to estimate group-specific welfare tradeoff ratios. It thus predicts that the targets will be categorized as a function of who receives the food (the group vs. the target himself) and that targets who provision the group will be viewed more positively.

4.1. Method

Seventy-six students (36 female) at UCSB participated. The procedure was identical to Study 1 with two exceptions. First, half the targets were paired with diagnostic sentences depicting them as paying a large cost to provision the group, whereas the other targets were paired with diagnostic sentences depicting them as provisioning the group and then paying a large cost to acquire food for personal use. For example, "He exposed himself to the hazardous waves on the rocks of the bay so he could catch sea bass to bring to the group" versus "After providing some food for the group, he waded through a river full of deadly piranhas to hunt duck for himself." These stimuli work against the alternative hypothesis that individuals incurring a large cost on behalf of the group will be viewed more positively due to higher ability, because these individuals produce less food overall. The second change from Study 1 was that the cover story now explicitly said that it was acceptable for foragers to sometimes personally consume food instead of contributing it. Thus, personally consuming the food was not a violation of an explicit agreement. The rating items were identical to Study 2.

4.2. Results

4.2.1. Are people who provide personal versus group benefits at a large cost categorized separately?

Yes. Subjects categorized targets separately based on who the targets provisioned at a large cost: the group or the target himself. Categorization scores for the diagnostic sentences were reliably greater than zero, mean±S.D.=2.25±3.90, t_{75}=5.04, p<.0001, r=.50. Categorization scores for the nondiagnostic sentences were not different from zero, mean±S.D.=0.40±3.65, t_{75}=0.96, p=.17, r=.11.

4.2.2. Are people who pay a large cost to provision the group viewed more positively?

Yes. Relative to targets benefiting themselves at a large cost, subjects' viewed targets who provisioned the group at a large cost more positively on all items, all ps<.001 and all rs≥.42. Importantly, subjects viewed targets who incurred large costs to benefit the group as feeling more altruistic toward the group (r=.42) and as being more desirable as a group member (r=.49). As in the earlier studies, targets who incurred large costs on behalf of the group were viewed as more competent. This occurred despite the other targets actually finding more food, suggesting that social factors can influence perceptions of competence.

5. Studies 4 and 5: varying benefits provided

Studies 1–3 provided consistent evidence that targets willing to incur greater costs on behalf of the group were categorized separately from those who incurred small costs. Moreover, they were viewed more positively, including on items about their valuation of the group (e.g., targets' altruism and care toward the group) and their value to others (e.g., targets' own desirability as a group member). That costs are encoded is not a straightforward prediction of an asocial foraging perspective. Indeed, this approach might predict that people who pay more to deliver the same benefits—that is, have lower efficiency—might be viewed less positively.

Studies 4 and 5 further tested predictions that separate a welfare tradeoff approach to resource pooling from an asocial foraging approach. These studies manipulated the amount of benefits provided. According to welfare tradeoff theory, variations in benefit delivery should be weakly or not at all encoded when they cannot reveal underlying differences in welfare tradeoff ratios; a social exchange or asocial foraging approach most directly predicts strong encoding of variations in benefit delivery. To arbitrate this, new descriptions were created. Half the targets in Studies 4 and 5 were twice depicted as providing a very small benefit (e.g. a small handful of nuts); each of the remaining half were twice depicted as providing a very large benefit (e.g. a very large amount of fruit). These differences are not revealing of underlying welfare tradeoff ratios because, in the harsh environment depicted in the scenario, it is random with respect to effort whether a person will encounter a large or a small resource. All targets paid the default costs of searching the island for food; only chance determined what resources they would find.

To manipulate the richness of the environment, Studies 4 and 5 used different sets of background events (i.e., nondiagnostic sentences). Study 4 used the same nondiagnostic sentences as previous studies, ones that depicted all targets providing a medium-sized benefit at default costs. This causes the environment to appear relatively resource rich—all targets always find at least something. If positive sentiment is preferentially directed at targets finding *large* benefits in Study 4, it could be that subjects perceive targets finding *small* benefits as making poor decisions—why settle for a handful of nuts when you can find a bushel of fruit? To test against this in Study 5, in the nondiagnostic sentences, all the targets failed to find any food. Thus, resource acquisition was not certain. A manipulation check at the end

of Study 4 showed that subjects perceived the large benefits as much more beneficial than the small benefits (r=.83, p<.001). Although subjects noticed the sizes of the benefits, will this difference affect perceptions of the targets?

5.1. Methods

Forty-three students (24 female; Study 4) and 57 students (29 female; Study 5) at UCSB participated. The procedure was identical to Study 1 with the following exceptions. In Studies 4 and 5, for half the targets, their diagnostic sentences depicted them finding a small benefit; for the remaining targets, diagnostic sentences depicted them finding a large benefit. In both cases, targets paid a cost greater than the default cost of foraging. For example, "He got food for the group by climbing one the highest trees on the island to collect the few cashews he saw at the top" versus "He noticed a large patch of peaches in the grove at the top of a perilous cliff and climbed up to gather loads to bring back for the group." In Study 4, the nondiagnostic sentences were identical to the previous studies' and depicted targets as finding a medium benefit at a default cost. In Study 5, the nondiagnostic sentences all depicted targets as failing to find a benefit at a default cost. For example, "He searched all over the island but found no food to bring back." The rating items were identical to Study 2.

5.2. Results

5.2.1. Are people finding large versus small benefits categorized separately?

No. As predicted, the categorization measure showed that subjects did not encode differences in benefits provided. Categorization scores for diagnostic sentences were not reliably different from zero (and were in the wrong direction) in Study 4 and Study 5, respectively: Mean±S.D.= −0.15±2.44, t_{42}=−0.41, p=.34, r=−.06; mean±S.D.= −0.29±2.25, t_{56}=−0.96, p=.17, r=−.13. This was also true for nondiagnostic sentences, Study 4 and Study 5, respectively: mean±S.D.=0.48±2.94, t_{42}=1.06, p=.15, r=.16; mean±S.D.=−0.07±2.77, t_{56}=−0.18, p=.43, r=.02. Thus, whereas the categorization effect sizes for diagnostic sentences for Studies 1–3 were quite large (rs ranged from .44 to .62), the comparable effects in Studies 4 and 5 were not only quite small (absolute rs=.06 and .13) but were also descriptively in the wrong direction.

5.2.2. Are people viewed differently based on the size of the benefits they provide?

There was some tendency for targets who provided larger benefits to be viewed more positively, although the sizes of the effects were relatively small (Tables 1 and 2). For Study 4, rs ranged from .03 to .32 (ps from .03 to .82); for Study 5, rs ranged from .08 to .28 (ps from .03 to .53). Although all impression measures favored individuals providing large benefits, the effect sizes in Studies 4 and 5 (median≈.20) were smaller than those in Studies 1–3 (median=.48,rs ranged .14 to .61). These results suggest that benefits delivered play some role in person perception: All else being equal, more efficient foragers make better partners. Nonetheless, the total pattern of results is not consistent with an asocial optimal foraging account; this view cannot straightforwardly predict the greater emphasis on costs incurred over benefits provided.

6. General discussion

Successful resource pooling allows individuals who experience temporary shortfalls due to illness, injury, or bad luck to receive resources or aid. Such a system cannot be maintained, however, if partners are chosen based on criteria used for asocial optimal foraging, such as return rate. Using this metric, individuals would be excluded from sharing at the times when they need it most. Instead, the mind needs ways to "see through" temporary shortfalls and extract information that predicts who will be valuable long-term sharing partners. A welfare tradeoff approach to resource pooling predicts that variations in costs incurred can be used to infer a person's underlying valuation of a resource pooling system, which in turn affects their value as a partner. Studies 1–3 tested this by manipulating costs incurred on behalf of a resource pooling system while holding the benefits provided constant. All three studies showed that (a) people were categorized separately depending on whether they incurred large or small costs, (b) people incurring large costs were seen as more highly valuing the group, and (c) people incurring large costs were preferred as group members. Welfare tradeoff theory further predicts that when variations in costs and benefits are not revealing of underlying psychological variables, then they should play little role in person perception. Studies 4 and 5 tested this by manipulating benefits provided while holding costs incurred constant; importantly, manipulations in benefits were random with respect to people's decisions and thus did not reflect underlying psychological variables. Both studies showed that (a) categorization did not occur based on variations in benefits provided and (b) although positive sentiment was somewhat directed at individuals providing large benefits, the effects were much smaller than those in Studies 1–3.

Although the results are consistent with a welfare tradeoff approach to resource pooling, they are not straightforwardly predicted by an asocial optimal foraging approach or by social exchange approaches. These approaches would more easily predict that benefits will loom larger than costs in person perception. Across five studies, however, we found the opposite: costs incurred had a larger effect than benefits provided. We stress that the human mind surely does contain asocial foraging mechanisms; our claim is simply that such mechanisms cannot explain the full breadth of human foraging and social behavior. We also do not claim that benefits never play a role in person perception. Indeed, they can when they are revealing of underlying psychological

variables, such as in recent work on welfare tradeoff theory (Sell, 2005) or in seminal work on the determinants of gratitude and helping (Tesser et al., 1968; Greenberg et al., 1971). We suspect that benefits are often revealing because, in many situations, benefit size predicts the costs incurred (e.g., a recipient can probably infer that a gift of an all-expense-paid cruise is more costly than a ceramic coffee mug). The size of the benefits a person delivers, moreover, might also predict the person's ability to produce; past research shows that ability or competence is a central dimension of person perception (Cuddy, Fiske, & Glick, 2008).

The present studies operationalized a resource pooling relationship as a group brought together because their survival required cooperation. However, communal relationships come in a variety of forms and from a variety of sources: kinships, friendships, mateships, long-enduring coalitions, parent–offspring relationships, and so on. Although diverse, these various types of relationships can all become resource pooling relationships when they involve long-term, mutual provisioning of benefits without strict account-keeping. Whenever this is true, maintaining the relationship requires ignoring short-term fluctuations in the benefits received and instead focusing on the underlying psychological variables that regulate behavior. This can be distinguished from other types of relationship structures, such as what Fiske (1992) calls market pricing. Market pricing relationships conform much more to the type of relationship envisioned in an asocial foraging account: Here, the mind focuses on the net returns available from others; the costs others incur do not matter. Exchanging money for a meal at a fast food restaurant is a prototypical market pricing transaction. Clearly, not all human interactions—even those of a broadly economic nature—take this form.

Future research could explore how the variability of resource acquisition affects the impact of costs and benefits. If the mind is sensitive to differences in variability, theory would predict that as resource acquisition becomes more certain or the likelihood of being in need declines, the relative impact of costs versus benefits should change. In highly variable environments, return rate is not closely coupled to effort expended—randomness plays a large role in acquisition. In predictable, stable environments, return rate is closely coupled to effort—greater effort will be closely linked to acquisition. In this case, benefits provided may be about as informative as cost incurred for estimating underlying psychological variables. Moreover, stable environments lower the utility of resource pooling relationships. Thus, in stable environments, there may be less motivation to form such relationships.

Although our methodology allowed for tightly controlled experimental rigor, it has the downside of lacking real-world validity. Our experimental results converge, however, with observational data collected in ethnographic settings. For instance, Gurven et al. (2000) studied sharing among the Ache, a group of forager–horticulturalists from Paraguay. In their sample, individuals who shared a large percentage of food they acquired—even if they acquired relatively little—were selectively targeted for aid in times of need. Conversely, simply acquiring large amounts of food was not enough to elicit much sharing from others: Those individuals who acquired a lot but shared little as a percentage were not especially likely to receive aid.

Our results provide preliminary experimental evidence for one aspect of a psychology designed for social foraging. These psychological mechanisms appear to embody the constraints imposed by a resource pooling system, allowing the mind to ignore day-to-day variability in foraging returns and instead assess the underlying variables that guide others' behavior. Their operation allows humans to survive disabilities that few other animals could. Although survival in an uncertain world is difficult, at least we do not face it alone.

Acknowledgments

This work served as part Andrew Delton's dissertation. We graciously thank the committee members for their feedback: Leda Cosmides, John Tooby, Daphne Bugental, Tamsin German, and Nancy Collins.

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