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RESEARCH ARTICLE

The Skillful and the Stingy: Partner Choice Decisions and Fairness Intuitions Suggest Human Adaptation for a Biological Market of Cooperators

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Abstract Despite the importance of human cooperation, the psychological mechanisms by which humans choose their cooperative partners and divide the spoils of cooperation are still unclear. To address these questions, we first contextualize human cooperation within biological market theory and then present results from a series of economic games in which we test how a cooperative partner's generosity and productivity affect their desirability as a partner and intuitions about how entitled they are to keep the spoils of cooperation. We found that the evaluation of productivity and generosity cannot be fully explained by the incentive structure of the game, but appeared calibrated for choosing long-term cooperative partners and dividing cooperatively created resources within a biological market. Specifically, productivity mattered more to men than to women, and productivity mattered more when it revealed underlying skill rather than luck. In addition, generosity had far larger effects than productivity, but the effect of productivity was moderated by generosity, suggesting sophisticated heuristics for choosing cooperative partners. We discuss implications of our data for the study of social perception and suggest avenues for future research.

Keywords Partner choice · Fairness · Trust game · Cooperation · Social cognition · Evolutionary psychology

Introduction

The ability to choose cooperative partners likely contributed to the evolution of cooperation (e.g., Aktipis 2004) and created biological markets in which individuals compete to choose and be chosen by the best available partners (Noë and Hammerstein 1994, 1995). There is evidence of such cooperative marketplaces in nonhuman species (e.g., Barrett and Henzi 2006; Bshary and Noë 2003), and research suggests that humans also choose cooperative partners on the basis of dispositional cooperativeness: people exhibit strong preferences for more generous and cooperative partners (e.g., Delton and Robertson 2012), vigilance against cheating in social relationships (Cosmides and Tooby 1992), and even tendencies to compete to appear generous under conditions that allow partner choice (Barclay and Willer 2007; Roberts 1998).

Although the partner choice literature to date has focused on prosociality and generosity in potential cooperative partners, there is reason to think that partner preferences should also be informed by potential partners' productivity (Barclay 2013, 2016). A cooperative partner who produced many material resources (e.g., from exceptional skill in hunting) could in principle have provided a larger stream of fitness benefits than a less skilled but more generous partner. Some nonhumans choose partners based on competence (e.g., Melis et al. 2006; Vail et al. 2014), and anthropological work has found that individuals or households with productive reputations receive more help from others (Gurven et al. 2000; Macfarlan and Lyle 2015). Likewise, recent research demonstrated that individuals with facial cues of ancestral forms of productivity (e.g., the ability to successfully hunt or gather

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food in the wild) received preferential treatment in an economic game (Eisenbruch et al. 2016), suggesting subjects' sensitivity to cues of productivity as well as generosity.

Very little research has addressed how cues of generosity and productivity may combine or be traded off against one another in cooperative partner evaluations. Raihani and Barclay (2016) asked participants in an economic game to choose between partners who varied in both wealth and generosity. They found that a plurality of participants chose a poor-fair partner over a rich-stingy partner (49.5 and 37.3%, respectively, with 13.1% reporting no preference), even though there was a monetary incentive to choose the rich-stingy partner. Though the preference for the fair partner was not statistically significant, this provides evidence that people may weigh a partner's generosity more heavily than their wealth. Here, we used a trust game to further examine how subjects integrate varying cues of partner productivity and generosity, how sex and context cues affect their relative importance, and how cues of productivity and generosity affect perceptions of fairness in addition to partner choice decisions.

In the present games, subjects chose how much money to send to a partner; that money was then multiplied by a factor determined by the partner's ostensible performance on a task; the partner then elected to return a fraction of the multiplied amount to the subject. The multiplier was thus a manipulation of partner productivity—i.e., the resources generated via their performance—and the percent returned a manipulation of their generosity. Since productivity and generosity made identical contributions to game earnings, any differences in these variables' effects on subjects' reactions to their partners cannot be explained by monetary incentives and would instead provide clues about how partner choice mechanisms weigh these two components of partner value.

We employed two dependent variables to test how partner productivity and generosity are weighed. First, we had a direct measure of partner choice: participants either chose or rejected a partner for future rounds of the game after learning their levels of productivity and generosity. Second, we tested the effects of productivity and generosity on perceptions of fairness. Biological market theory suggests that more valuable partners are entitled to more advantageous resource distributions, so intuitions about "fair" distributions should track cues of partner value (Baumard et al. 2013). Eisenbruch et al. (2016) found that apparently valuable partners received higher offers and lower demands in a bargaining game, suggesting that intuitions about how resources should be divided reflect biological markets, in which individuals bid for relationships with more valuable partners. Therefore, we tested the effects of partners' productivity and generosity on perceptions of how fair their distributions of the cooperatively created resource were.

Since productivity is a relatively new topic in the partner choice literature (Eisenbruch et al. 2016; Macfarlan and Lyle 2015; Raihani and Barclay 2016), we were also interested in the design of the preference for productivity. Is the preference for productive partners based on a calculation of the payoffs they can offer in a specific encounter, or does it reflect specialization for ancestral long-term cooperative relationships? To answer this question, we tested whether sex and two framing manipulations affected the importance of partner productivity. Because ancestral men (more so than women) cooperated in the domains of large-game hunting and coalitional warfare (e.g., Marlowe 2007, 2010; Wrangham 1999)—domains in which returns have high variance and skill rankings are publicly known (Apicella 2014; Kaplan et al. 1985; von Rueden et al. 2008)—men may place greater weight on a partner's productivity, compared to women. Consistent with this, research suggests that men's social relationships and preferences are oriented toward maintaining access to productive cooperative partners, while women place more weight on emotional intimacy and warmth (e.g., Benenson et al. 2014; Fiske et al. 2007; Hall 2011; Lewis et al. 2011; Vigil 2007). We therefore predicted that partner productivity would have a greater effect on men's partner choice decisions and fairness judgments, compared to women's (Hypothesis 1).

We also employed two framing manipulations to test the specialization of the productivity preference. First, if the productivity preference evolved in the context of long-term cooperative relationships, then it should be sensitive to cues of a partner's ability to generate benefits over the course of repeated future interactions, rather than the benefits offered in the present interaction (see Delton et al. 2011). Therefore, we manipulated whether a partner's performance was indicative of their stable skills (and therefore their ability to generate future benefits), vs. being based on luck. We predict that skill-based productivity will have a greater effect on partner choices and fairness judgments than will luck-based productivity (Hypothesis 2). Second, if ancestral humans engaged in multiple types of cooperation, then evaluations of partner value may be specialized for those different types of cooperation. In risk pooling, partners reciprocally provision each other when one is needy and the other has a surplus (Trivers 1971). Since risk-pooling partners effectively serve as insurance policies, any cues of a risk-pooling partner's level of caring or desire to cooperate may be paramount (e.g., Delton and Robertson 2012; Tooby and Cosmides 1996). However, in collaboration (e.g., coalitional violence and large-game hunting), partners coordinate their actions in order to produce greater resources than either would be able to produce alone (e.g., Marlowe 2010; Wrangham 1999). Therefore, since collaborative relationships effectively serve to increase individual productivity, we predict

that productivity will have a greater effect on partner choices and fairness judgments for collaboration partners than risk-pooling partners (Hypothesis 3).

Study 1

Study 1 Methods

Study 1 Participants

We recruited Amazon Mechanical Turk workers in the USA. One hundred twenty-six participants began the study, and 109 completed it and reported their sex. There were 28 women in the risk-pooling condition, 24 women in the collaboration condition, 24 men in the risk-pooling condition, and 33 men in the collaboration condition. The mean age of these participants was 34.09 years (s.d. = 12.16); 4.6% of the participants reported having a high school diploma or GED, 36.7% had some college education, 47.7% had completed college, and 11% had a graduate or professional degree.

Study 1 Design

Subjects were given a $10 budget and could choose to send any amount to their partner. The money they sent to their partner was multiplied by either 3, 4, or 5 (the partner's "productivity"), and the partner then returned either 30, 40, or 50% of the new total to the subject (the partner's "generosity"). After learning the partner's productivity, generosity, and how much money they received back, subjects indicated how fair the partner's behavior was, and whether they would like to play another round with the same partner (for up to 3 consecutive rounds with each partner). Note that productivity and generosity make symmetrical contributions to the subjects' earnings, so an income-maximizer would have equal preferences for the two traits (Table 1). We used sham partners in order to perfectly manipulate productivity and generosity; subjects were told that they were playing with past participants whose decisions for every contingency had been previously recorded.[1] Subjects were actually paid for the outcome of one randomly selected round. We also employed a framing manipulation in order to vary the cues relevant to H2 and H3 (see below). Thus, our design included one between-subjects factor (framing manipulation) and two within-subjects factors (partner productivity and generosity), in addition to subject sex as a between-subjects participant variable.

[1] A reviewer expressed concern over the use of deception on Amazon Mechanical Turk, suggesting that it may foster suspicion in the participant pool. Though evidence on the effects of experimental deception is mixed, we acknowledge this concern and welcome the development of evidence-based rules governing the use of deception or incomplete information in online studies.

Table 1 Returns (in dollars) per dollar sent to the partner, across all levels of partner productivity and generosity

Generosity (%)	Productivity		
	3	4	5
30	0.90	1.20	1.50
40	1.20	1.60	2.00
50	1.50	2.00	2.50

Study 1 Procedure and Materials

Subjects agreed to participate and then read an introduction to the game, which varied based on random assignment. In the risk-pooling condition, they were told that they would play the "osotua game," modeled after risk-pooling relationships among the Hadza. These relationships were described as social insurance against hard times, whereby partners give each other resources whenever one needs help. In this condition, participants were told that the partners' productivity was based on "how 'lucky' the partners were randomly assigned to be." In the collaboration condition, subjects were told they would play the "asatua game," modeled after collaborative relationships among the Hadza. These relationships were described as opportunities to work together to create resources that neither partner would be able to create alone. In this condition, participants were told that the partner's productivity was based on "how well your partner performed on a difficult general knowledge and problem-solving test." See Section S1 for full text of these framings. Next, participants were instructed in the structure of the game (see Design).

At the start of the first round with each partner, participants were told that they were beginning play with a new partner. Under a header saying "round 1," participants chose how much of their $10 budget to send to their partner (in $1 increments). On the next screen, participants were told how much the partner's money had been multiplied by, what percentage of the money the partner had returned to them, and how much money they had received back from the partner. In order to measure perceptions of the partner's fairness, we capitalized on the function of anger and gratitude as recalibrational emotions (Tooby and Cosmides 2008). According to this account, an individual experiences anger when they are treated less well than they think they should be, while gratitude is elicited when an individual receives better treatment than they expected. Thus, anger indicates that a behavior was perceived as unfair (i.e., below the treatment that an individual can expect in the marketplace of cooperators; Baumard et al. 2013), while gratitude indicates that a behavior was perceived as fair or favorable. Therefore, on the same screen as the results of each round, participants were asked to indicate on 7-point Likert-type scales how angry and how grateful they felt toward their partner, and chose to either play another round with the same partner or switch to a new partner for the next round. If the

participant chose to play again with the same partner, this procedure was repeated for up to 3 rounds, with the header changing to reflect the round number (after the third round, the participant was told they would have to switch to a new partner for the next round, but were asked to indicate if they would hypothetically like to play with the present partner again). In cases where the participant chose to keep playing with the same partner, the partner's behavior was consistent across all three rounds. If the partner chose to switch to a new partner, they restarted this sequence with a new partner.

This procedure was repeated for all nine possible partners (3 productivity levels × 3 generosity levels) in a random order. Participants therefore played between 9 and 27 rounds of the trust game, depending on their decisions to keep or switch partners. Following game play, participants completed two brief questionnaires that are not relevant to the present results, answered demographic questions, were debriefed about the true nature of the study (including that "osotua" is a form of helping relationship that exists among the Maasai, while "asatua" was invented for this experiment), and consented to the use of their data. The debriefing included an open-ended solicitation of comments about the study; none of the participants expressed suspicion regarding the manipulation or the use of sham partners.

Study 1 Analysis

We analyzed the effects of partner generosity and productivity as within-subject factors, and sex and condition as between-subject factors, using multilevel regression in SPSS with a random intercept at the subject level. (When analyzing partner choice decisions, we used a binary logistic link.) Productivity and generosity levels were coded as −1, 0, and 1, representing low, medium, and high, respectively. Females were coded as −0.5 and males as 0.5, and condition was coded as −0.5 for risk pooling and 0.5 for collaboration. A positive sex by productivity interaction predicting partner choice and fairness judgments would support H1 (the hypothesized sex difference in preference for productivity), while a positive condition by productivity interaction would support H2 (the hypothesized luck vs. skill effect) and H3 (the hypothesized risk pooling vs. collaboration effect).

A reviewer pointed out that more productive partners provided higher earnings at any level of generosity (e.g., a high-productivity partner returning 40% provides more money than a low-productivity partner returning 40%), so a positive effect of productivity on fairness judgments could be a response to the amount of money received, rather than to perceptions of entitlement. Therefore, we tested the effects of productivity and generosity on fairness judgments both with and without controlling for the amount of money received from the partner, in order to ensure that the effect of productivity on fairness perceptions is not merely a response to the absolute earnings received.

Study 1 Results

Anger and gratitude responses were negatively correlated ($r = -0.60$, $p < 0.001$), so we used the mean of gratitude and anger (reverse-coded) as our fairness composite. For clarity, we will highlight here only the results that directly bear on our research questions; Table S1 contains full regression results. We will first present the results for fairness judgments and then for partner choice decisions. For each dependent variable, we examine the main effects of productivity and generosity, test their interaction, and then test H1–H3.

Fairness Judgments: How Are the Preferences for Productivity and Generosity Integrated?

In a model with generosity and productivity predicting fairness judgments (Table S1, model 1), both generosity and productivity have significant positive effects. Mean fairness judgments increased by 1.02 points (out of 7) for each additional increment of generosity (coefficient = 1.02, $p < 0.001$, 95% CI = 0.97–1.07), and by 0.17 points for each additional increment of productivity (coeff = 0.17, $p < 0.001$, 95% CI = 0.12–0.22). Thus, even though productivity and generosity made equal contributions to game earnings, generosity had a much stronger effect on fairness judgments than productivity did (Fig. 1). Productivity retained a marginally significant (though diminished) effect on fairness judgments when controlling for the amount of money received from the partner (Table S1, model 2), suggesting that the perception that more productive partners were fairer was not solely caused by these partners providing higher earnings.

Adding an interaction term to this model (Table S1, model 3) reveals a significant interaction (coeff = −0.12, $p < 0.001$, 95% CI = −0.18 to −0.06). Figure 1 shows that a partner's productivity had a stronger effect on fairness judgments when they are stingy than when they are highly or moderately generous, even though productivity has a stronger effect on actual payoffs from highly generous partners (see Table 1).

Fairness Judgments: H1—Do Men Care more About Productivity than Women Do?

Sex did not moderate the effect of productivity or generosity on fairness judgments (Table S1, model 4), failing to support H1. However, additional analyses show that sex moderated the productivity by generosity interaction on fairness judgments, such that the interaction was found only among men (see Section S2). This suggests that for men's fairness decisions, but not for women's, a partner's productivity becomes more important when that partner is low on generosity.

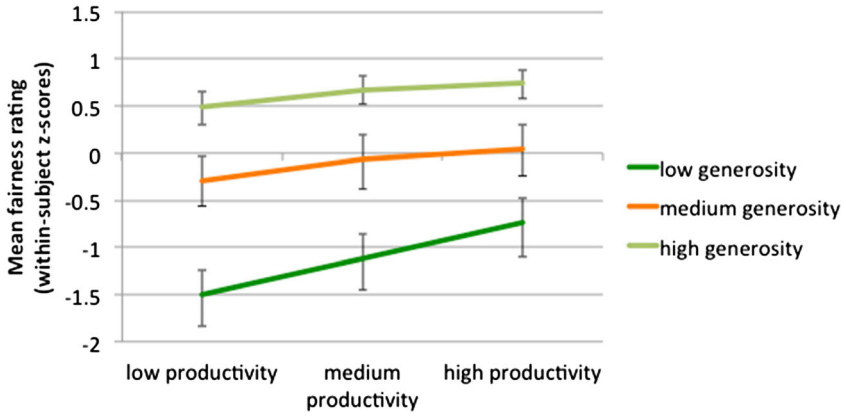

Fig. 1 Effects of productivity and generosity on fairness judgments (study 1). *Y*-axis represents means of within-subject standardized fairness ratings. *Error bars* are 95% CI

Fairness Judgments: H2 and H3—Does Productivity Matter more in the Collaboration Condition?

Condition moderated the effect of productivity on fairness judgments, such that productivity mattered more in the collaboration condition (coeff = 0.14, p = 0.009, 95% CI = 0.03–0.24; Table S1, model 5 and Fig. S2), supporting H2 and H3. This shows that productivity had a greater effect on fairness judgments when productivity reflects skill than when productivity is based on luck, even though productivity contributed to payoffs equally in both conditions. Condition did not moderate the effect of generosity on fairness judgments.

Partner Choice Decisions: How Are the Preferences for Productivity and Generosity Integrated?

In a model with generosity and productivity predicting decisions to stay with a partner (Table S1, model 6), productivity had a significant positive effect (odds ratio = 1.75, p < 0.001, 95% CI = 1.50–2.05) and generosity had a much larger positive effect (OR = 7.46, p < 0.001, 95% CI = 6.17–9.01). See Fig. 2 for a depiction of these effects. Thus, even though productivity and generosity made equal contributions to game earnings, the preference for generous partners appears to be much stronger than the preference for productive partners. Adding the interaction term to this model shows that the interaction term is not significant (Table S1, model 7).

Partner Choice Decisions: H1—Do Men Care more About Productivity than Women Do?

Sex did not moderate the effect of productivity or generosity on partner choice decisions (Table S1, model 8), thus failing to support H1.

Partner Choice Decisions: H2 and H3—Does Productivity Matter more in the Collaboration Condition?

Condition marginally moderated the effect of generosity on partner choice decisions, such that the effect of generosity was greater in the risk-pooling condition, but condition did not moderate the effect of productivity (Table S1, model 9; Fig. S3). Though we framed H3 in terms of productivity, this is consistent with our hypothesis that partner choice criteria will differ for different types of ancestrally recurrent cooperation, with a partner's generosity being more important in a risk-pooling partner than in a collaboration partner, even when the payoff structures are the same.

Study 1 Discussion

Though results were mixed, the findings of study 1 suggest that people's partner choice decisions and fairness judgments may be calibrated for a biological market of long-term cooperators, rather than being solely responsive to the incentive structure of the game. Turning first to partner choice decisions, a partner's productivity and generosity each predicted how frequently a partner was chosen for the second round of the game, with generosity having a much stronger effect (even though productivity and generosity contributed equally to payoffs). The effect of generosity on partner choice decisions was even stronger when the game was framed as an opportunity for risk pooling rather than collaboration (even though the framing did not change the payoff structure of the game), suggesting that humans may recalibrate their partner choice heuristics based on cues of different ancestrally recurrent types of cooperation. This may be due to an evolutionary history of risk-pooling relationships serving as social insurance against hard times (e.g., Sugiyama 2004; Trivers 1971), such that any cues of a partner's caring (in this case, their generosity) take on increased importance relative to other relationship types.

Turning next to fairness judgments, it is perhaps unsurprising that partner generosity strongly predicted fairness

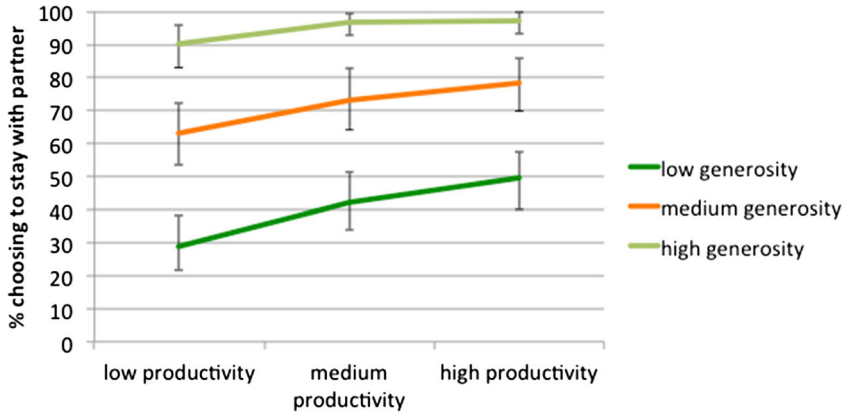

Fig. 2 Effects of productivity and generosity on decisions to play another round with a partner (study 1). *Error bars* are binomial 95% CI based on 1000 bootstrap samples

judgments, but there was also a significant main effect of productivity such that any given percentage returned by the partner was considered fairer the more productive that partner was. Productivity retained a marginally significant effect on fairness judgments even when controlling for the amount of money received from the partner, implying that the response to productivity was not simply a response to earnings. This suggests that being productive effectively entitles a partner to greater selfishness, consistent with biological market theory. The effect of productivity on fairness judgments was qualified by an interaction between productivity and generosity, such that generosity had a greater effect on fairness judgments among low-productivity than high-productivity partners (and vice versa). This suggests a conditional weighting of partner traits in fairness judgments: generosity is always important, but individuals who are selfish *and* unproductive are viewed as especially unfair. A three-way interaction showed that this conditional calculation of fairness existed among men, but not women (see Section S1). In addition, productivity had a stronger effect on fairness judgments in the collaboration condition (when it was based on stable skills, and therefore contained predictive information about future productivity), than in the risk-pooling condition (when it was based on luck). This shows that judgments of a partner's entitlement to a resource are sensitive to their long-term partner value, not merely their immediate contribution to the resource. Note that these patterns cannot be explained by the payoff structure of the game but may conform to the demands of an ancestral biological market.

This study has several limitations, however. The first is that the sample size (approximately 25 people per cell) may have been insufficient. Second, is that it is unclear how salient our cue of the partners' productivity was. Having performed well on a general knowledge and problem solving test may not strongly trigger intuitions about the types of productivity that would have mattered to our ancestors. Perhaps most seriously, the framing manipulation confounded the relationship type and the source of the partners' productivity. In the risk-pooling condition, the partners' productivity levels were a function of luck, while in the collaboration condition, they were based on test results. We made this design decision because risk-pooling relationships function to regulate variance in luck while collaboration functions to enhance productivity, but nonetheless, this creates a problem of interpretation. For example, we cannot tell whether the interaction between condition and productivity in predicting fairness judgments is due to different heuristics for risk-pooling vs. collaborative relationships, or whether the importance of productivity changes based on whether it is attributable to skill vs. luck. We conducted studies 2 and 3 in order to address these limitations.

Study 2

Study 2 Methods

Study 2 Participants

We recruited Amazon Mechanical Turk workers in the USA. Our goal was to have 50 men and 50 women in each condition. Three hundred ninety-nine people began the study; 235 of them successfully completed the comprehension check, and 208 of those people successfully passed the attention check. Two hundred seven of those people agreed to the use of their data, comprising our final sample. There were 48 women in the luck condition, 52 women in the skill condition, 53 men in the luck condition, and 54 men in the skill condition. Mean age of the sample was 33.44 years (s.d. = 10.15); 11.1% of the participants reported that they had a high school diploma or GED, 33.3% had some college education, 43% had completed college, and 12.1% had a graduate or professional degree.

Study 2 Design

Study 2 was designed to more clearly test whether the nature of a partner's productivity (revealing of the stable ability to create benefits vs. not) moderates the effect of productivity on partner choice and fairness judgments. If subjects' preference

for productive partners is calibrated for long-term partner choice, then subjects should be especially sensitive to cues of productivity that are revealing of the partner's intrinsic ability to create benefits (i.e., based on skill, physical fitness, etc.), because that ability would predict benefits generated over the long run. Productivity based on luck, however, does not predict the ability to generate benefits in the future, so it should have less of an effect on long-term partner choice mechanisms. On the other hand, if subjects choose and respond to their partners based on monetary payoffs, they should be indifferent to the source of the partner's productivity, since this does not change the payoff structure of the game.

Study 2 used the same game structure as study 1 with two modifications: In order to conserve funds, subjects were paid half of their stated earnings from one round; and instead of playing multiple rounds with the same partner consecutively, subjects played one turn with each partner, and after learning the outcome of each turn had the choice to either play another turn with that partner later, or exclude that partner from later rounds of the game (though in fact the game had only one round).

Study 2 Procedure and Materials

As in study 1, participants agreed to participate and were instructed in the structure of the game. All participants were told that the partners' productivity levels were based on how well those partners had performed in a virtual reality foraging task; subjects randomly assigned to the "skill" condition were told that "success in the foraging game is mostly a function of skill, since it depends on the person's spatial intelligence, memory, hand-eye coordination and effort." Subjects randomly assigned to the "luck" condition were told that "success in the foraging game is mostly a function of luck, since it depends on whether the person happened to encounter patches with lots of available food."

Following the introduction, participants answered three multiple-choice questions designed to check their comprehension of the study. Only participants who answered all three questions correctly could proceed with the study.

At the start of each turn, subjects saw a screen that said "You will now start playing with a new partner," and were asked how much of their budget they wanted to send to their partner. The next screen reported how much the money sent to the partner had been multiplied by, what percentage the partner had returned, and how much the participant had consequently received from them. On the same screen, the participant was asked "How fair is the amount that your partner sent back to you?," and answered five questions pertaining to the partner's association value (how much they wanted to be friends with that partner in real life, how likely they would be to choose them as a business partner, how likely they would be to choose them as a spouse for their sister or brother, how likely they would be to choose them as a neighbor, and how much they would like to have a social relationship in real life; all questions were framed as being relative to the other partners in the game) on 7-point Likert-type scales, and indicated whether they wanted to keep or exclude the partner from the next round of the game.

This sequence was repeated for all nine partners in a random order. Randomly interspersed with the nine partners was one item designed to check that participants were paying attention; only participants who answered this item correctly were allowed to continue with the study. After playing once with all nine partners, participants answered demographic questions, were debriefed about the true nature of the study, and consented to the use of their data. Before being told the true nature of the study, participants were asked what they thought the study was about and to leave any other comments they had about the study; none of the participants expressed suspicion regarding the manipulation or the use of sham partners.

Study 2 Analyses

We adopted the same analysis strategy as in study 1. A sex by productivity interaction would support H1, and a condition × productivity interaction would support H2. We also used the same multilevel modeling approach to test the relationship of association value perceptions to fairness judgments. We predicted that judgments of fairness would be positively related to perceptions of association value, suggesting that the degree to which a person is entitled to keep a resource (i.e., the fairness of a distribution) is related to their perceived value as a long-term cooperator.

Study 2 Results

The five association value items were strongly intercorrelated (Cronbach's alpha = 0.975), so we used their mean as our association value measure. There was a strong relationship between association value perceptions and fairness judgments, such that for every 1-point increase in association value, fairness ratings increased by 1.00 points ($p < 0.001$, 95% CI = 0.98–1.03). This supports our prediction that people who are perceived as more valuable social partners and cooperators are also perceived as more entitled to keep cooperatively gained resources, but we are reluctant to overinterpret this result due to the correlational nature of the data.

Fairness Judgments: How Are the Preferences for Productivity and Generosity Integrated?

In a model with productivity and generosity predicting fairness judgments (Table S3, model 1), each additional increment of productivity increased fairness judgments by 0.26points (coeff = 0.26, $p < 0.001$, 95% CI = 0.20–0.31), while each additional increment of generosity increased fairness judgments

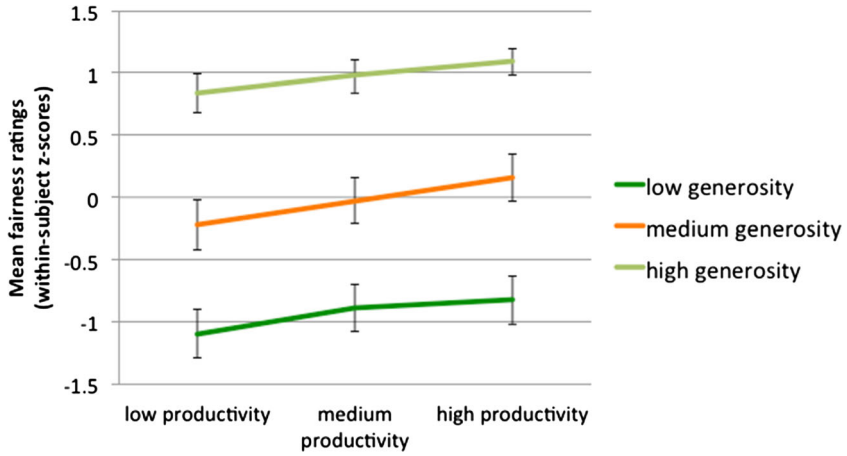

Fig. 3 Effects of productivity and generosity on fairness judgments (study 2). *Y*-axis represents means of within-subject *z* scores. *Error bars* are 95% CI

by 1.69 points (coeff = 1.69, $p < 0.001$, 95% CI = 1.63–1.75). This suggests that fairness intuitions are primarily based on generosity, but increasing productivity makes any given level of selfishness seem fairer (Fig. 3). Recall that productivity and generosity contributed equally to game payoffs, so the stronger effect of partner generosity is not responsive to earnings. The effect of productivity on fairness judgments remained significant and largely unchanged when controlling for the amount of money received from the partner; in fact, the money received was not a significant predictor of fairness judgments (Table S3, model 2). This suggests that the effect of productivity on fairness judgments was based on an assessment of partner value, rather than a response to absolute earnings. Adding the interaction term to model 1 reveals no interaction between productivity and generosity on fairness judgments (Table S3, model 3).

Fairness Judgments: H1—Do Men Care more About Productivity than Women Do?

Sex marginally moderated the effect of productivity on fairness judgments, such that men's fairness judgments were more affected by partner productivity than women's were, supporting H1 (coeff = 0.12, $p = 0.052$, 95% CI = 0.00–0.23; Table S3, model 4; Fig. S4). Sex does not moderate the effect of generosity on fairness judgments.

Fairness Judgments: H2—Does Productivity Matter more in the Skill Condition?

Both productivity and generosity had stronger effects on fairness judgments in the skill condition (productivity: coeff = 0.15, $p = 0.013$, 95% CI = 0.03–0.26; generosity: coeff = 0.12, $p = 0.038$, 95% CI = 0.01–0.24; Table S2, model 5; Figs. S5 and S6). The interaction between condition and productivity supports H2, while the interaction between condition and generosity was not predicted.

Partner Choice Decisions: How Are the Preferences for Productivity and Generosity Integrated?

In a model with productivity and generosity predicting partner choice decisions (Table S3, model 6), both productivity (OR = 2.24, $p < 0.001$, 95% CI = 1.89–2.67) and generosity (OR = 15.38, $p < 0.001$, 95% CI = 12.27–19.28) had significant positive effects on the odds of retaining a partner (see Fig. 4). This shows that people preferred productive partners, but the preference for generous partners was much stronger, even though productivity and generosity contributed equally to game earnings. Adding an interaction term to this model reveals a significant interaction between productivity and generosity (OR = 1.34, $p = 0.024$, 95% CI = 1.04–1.72; Table S3, model 7). As Fig. 4 shows, productivity had weak effects at high and low generosity but had a clear, stepwise positive effect at medium generosity.

Partner Choice Decisions: H1—Do Men Care more About Productivity than Women Do?

Sex did not moderate the effect of productivity on decisions to keep a partner for the next round of the game, but sex did moderate the effect of generosity such that women's decisions to keep a partner were more sensitive to generosity than men's were (OR = 1.59, $p = 0.050$, 95% CI = 1.00–2.52; Table S3, model 8; Fig. S7). While we framed H1 in terms of productivity, this result is consistent with our prediction that women's partner choice decisions would give greater relative weight to generosity and men's would give greater relative weight to productivity.

Partner Choice Decisions: H2—Does Productivity Matter more in the Skill Condition?

Condition marginally moderated the effect of productivity on decisions to keep a partner for the next round of the game,

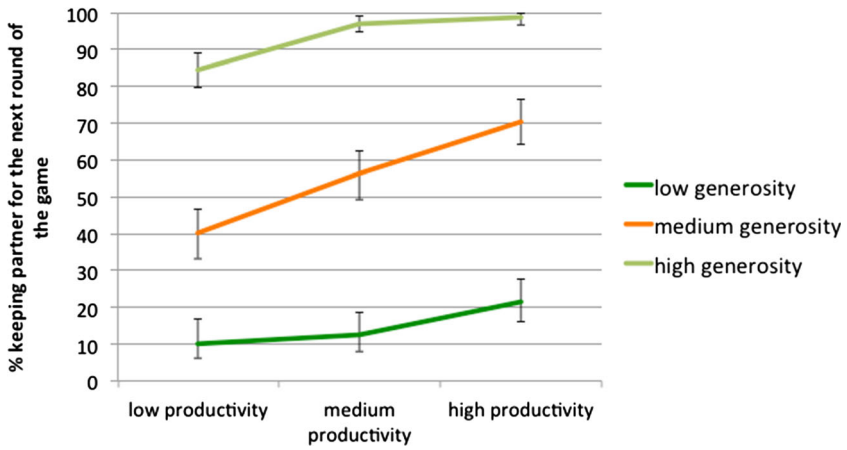

Fig. 4 Effects of productivity and generosity on decisions to play another round with a partner (study 2). *Error bars* are binomial 95% CI based on 1000 bootstrap samples

such that productivity had a stronger effect in the skill condition, supporting H2 (OR = 1.41, $p = 0.053$, 95% CI = 1.00–2.00; Table S3, model 9; Fig. S8). This suggests that the preference for productive partners is sensitive to a partner's ability to generate benefits in the future, not merely to the partner's immediate ability to confer benefits, even though game payoffs were the same in both conditions. Condition did not moderate the effect of generosity on decisions to keep a partner for the next round.

Study 2 Discussion

Study 2 provided a clearer picture of how the preference for productive partners is calibrated. Turning first to fairness judgments, both generosity and productivity had significant positive effects on fairness judgments, even controlling for the amount of money received from the partners. This shows that intuitions of fairness are not only based on quality of treatment (in this case, generosity) but also incorporate notions of different actors being entitled to different levels of selfishness, depending on their productivity. In effect, it was considered fairer for highly productive partners to offer selfish distributions than for unproductive partners to offer the exact same distributions. The effect of productivity on fairness judgments was stronger for men and stronger in the skill condition (supporting H1 and H2, respectively). These effects therefore suggest that fairness intuitions track cues of ancestral partner value, as predicted by biological market theory (Baumard et al. 2013).

Turning to partner choice decisions, both productivity and generosity had significant positive effects, but generosity had a much larger effect (as in study 1). The criteria of partner choice appeared to be nuanced and dynamic, however. Though the effect of productivity was not stronger for men (our H1), the effect of generosity was stronger for women, which is consistent with our argument regarding differences in cooperative partner preferences corresponding to sex-differentiated domains of cooperation. In addition, productivity had a stronger effect on partner choice decisions in the skill condition than in the luck condition, supporting H2. Recall that productivity in the skill condition was indicative of a partner's trait-like ability to generate benefits in the future, while productivity in the luck condition was not, even though productivity contributed equally to game payoffs in both conditions. This effect therefore suggests that people's partner choice decisions are sensitive to cues that someone will be a productive long-term cooperative partner, rather than being driven solely by short-term material gains.

Finally, the effect of productivity on partner choice decisions was moderated by generosity. Highly generous partners were nearly always desired (with a slight decrease for the especially unproductive), and highly selfish partners were nearly always undesirable (with a slight increase for the highly productive), but productivity had a stronger effect among partners of medium generosity.

Note that in study 1, productivity mattered most to fairness judgments at low generosity (but there was no productivity by generosity interaction predicting partner choice decisions), while in study 2, productivity mattered most to partner choice decisions at medium generosity (but there was no productivity by generosity interaction predicting fairness judgments). The inconsistency of these effects across studies 1 and 2 suggests the importance of reexamining them in study 3.

Study 3

Study 3 Methods

Study 3 Participants

We recruited Amazon Mechanical Turk workers in the USA. Our goal was to have 50 men and 50 women in each condition. Two hundred forty-two people began the study, and 201 passed the comprehension check and successfully completed the study. There were 50 women in each condition, 50 men in

the risk-pooling condition, and 51 men in the collaboration condition. Mean age of the sample was 34.58 years (s.d. = 10.32); 10.4% of the sample reported having a high school diploma or GED, 34.3% had some college education, 43.3% had completed college, and 11.4% had a graduate or professional degree.

Study 3 Design

Study 3 was designed to test whether productivity matters more to partner choice and fairness judgments in collaboration situations than in risk-pooling situations. We designed a task with the same underlying structure as studies 1 and 2 but revised the surface features in order to manipulate cues of collaboration vs. risk pooling. The task was for participants to imagine themselves as a hunter-gatherer choosing partners for either a collaborative foraging partnership or a risk-pooling foraging partnership, depending on condition. The foraging partners varied in productivity (such that their partnerships typically produced 30, 40, or 50 lb of food) and generosity (such that they typically shared 30, 40, or 50% of the food), so the hypothetical payoff structure of this game was the same as the payoff structures used in studies 1 and 2. Given the evidence from studies 1 and 2 that participant responses were not driven by monetary payoffs, we employed hypothetical rewards in study 3.

Study 3 Procedure and Materials

Subjects agreed to participate and then read a framing passage that varied by condition. In the risk-pooling condition, foraging partnerships ("osotua partnerships") were presented as a way for partners to smooth out the variations in luck that foragers are vulnerable to, by pooling their gains. In the collaboration condition, foraging partnerships ("asatua partnerships") were presented as a way for individuals to increase their productivity by working together. See S1 for full text of these framings. In both conditions, the participants were told that the partnerships last for 1 day, the older of the partners always divides the total food between the two of them, it would be unthinkable for someone to cheat their partner, and that reputations for foraging skill and generosity are well-known and can be taken into account when deciding whether or not to partner with someone.

Immediately following this passage, participants were asked three multiple-choice questions to check their comprehension. Only participants who answered all three questions correctly were permitted to continue the study. Next, participants were instructed that their task would be to imagine themselves as a hunter-gatherer deciding whether or not to join a specific same-sex person's foraging partnership on different days.

Before making these decisions, participants completed an "introduction round" in which they were told the productivity and generosity reputations of each of the nine people they would later make decisions about. Each person's information was presented on a separate screen in a random order, and said "One of the people is known as [a below-average forager / a roughly average forager / one of the best foragers in the group], and [he / she] usually gives [his / her] partner about [30 / 40 / 50%] of the total food acquired."

Following the "introduction round," participants proceeded to the "decision round." Each partner was presented on a separate screen, representing a different day on which the participant had been invited to join a different person's foraging partnership. For each partner, participants were told their productivity reputation (i.e., below average, about average, or among the best in the group) and the amount of food that their partnerships thereby generate on a typical day (in pounds), and what percentage of the food they usually share with their partner. The participants then decided whether or not they would like to join that person's foraging partnership for the day, and indicated on 7-point Likert-type scales how fair that person is in dividing the food with their partner, how grateful they felt toward that person for the invitation, and how angry they felt toward that person for the invitation. This was repeated for all nine partners in a random order. Following this "decision round," participants provided demographic data, were debriefed that osotua relationships exist among the Maasai but "asatua" relationships were invented for this study, and consented to the use of their data. Before being debriefed, participants were asked to leave any other comments they had about the study; none of the participants expressed suspicion regarding the manipulation.

Study 3 Analysis

We adopted the same analysis strategy as in studies 1 and 2. A sex by productivity interaction would support H1, and a condition by productivity interaction would support H3.

Study 3 Results

Judgments of fairness, gratitude, and anger (reverse-coded) were highly intercorrelated (Cronbach's alpha = 0.84), so we used their mean as our fairness DV.

Fairness Judgments: How Are the Preferences for Productivity and Generosity Integrated?

In a model predicting fairness judgments, productivity (coeff = 0.58, $p < 0.001$, 95% CI = 0.53–0.63) and generosity (coeff = 1.39, $p < 0.001$, 95% CI = 1.34–1.44) both had significant, positive effects (Table S4, model 1; Fig. 5). As in studies 1 and 2, fairness judgments were sensitive to a

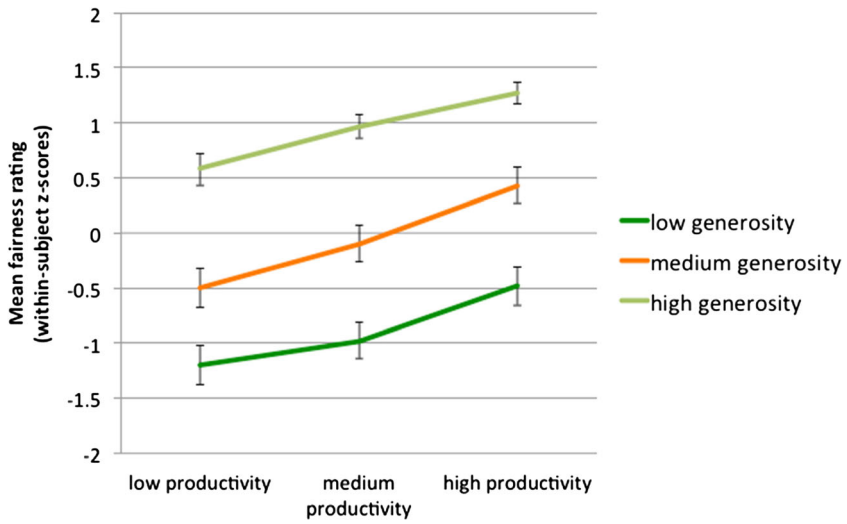

Fig. 5 Effects of productivity and generosity on fairness judgments (study 3). *Y*-axis represents means of within-subject *z* scores. *Error bars* are 95% CI

partner's productivity (increasing by 0.58 points for each additional increment of productivity) but were much more sensitive to a partner's generosity (increasing by 1.39 units for each additional increment). There was no interaction between productivity and generosity on fairness judgments (Table S4, model 2).

Fairness Judgments: H1—Do Men Care more About Productivity than Women Do?

Sex moderated the effect of productivity on fairness judgments, such that men's fairness judgments were significantly more influenced by a partner's productivity than women's were (coeff = 0.15, p = 0.004, 95% CI = 0.05–0.25; Table S4, model 3; Fig. S9), supporting H1.

Fairness Judgments: H3—Does Productivity Matter more in the Collaboration Condition?

Condition did not moderate the effect of productivity on fairness judgments. Condition moderated the effect of generosity on fairness judgments such that generosity had a stronger effect on fairness judgments in the collaboration condition than in the risk-pooling condition (coeff = 0.17, p = 0.001, 95% CI = 0.07–0.26; Table S4, model 4; Fig. S10). Even though we framed H3 in terms of productivity, this is conceptually contrary to our prediction.

Partner Choice Decisions: How Are the Preferences for Productivity and Generosity Integrated?

As in studies 1 and 2, participants preferred to join productive partners (OR = 6.10, $p < 0.001$, 95% CI = 4.96–7.51), but had a much stronger preference for generous partners (OR = 11.94, $p < 0.001$, 95% CI = 9.49–15.02) (see Table S4, model 5; Fig. 6).

There was a significant interaction between productivity and generosity predicting decisions to join a partner (OR = 1.37, p = 0.019, 95% CI = 1.05–1.79; Table S4, model 6). Figure 6 shows that productivity mattered most for medium-generosity partners, as in study 2. There is also evidence that high productivity compensates for low generosity: there was almost no effect of going from medium to high productivity among high-generosity partners, but a large effect of going from medium to high productivity among low-generosity partners.

Partner Choice Decisions: H1—Do Men Care more About Productivity than Women Do?

Sex did not moderate the effect of either productivity or generosity on decisions to join a particular foraging partnership (Table S4, model 7), failing to support H1.

Partner Choice Decisions: H3—Does Productivity Matter more in the Collaboration Condition?

Condition did not moderate the effect of productivity or generosity on decisions to partner with a particular person (Table S4, model 8), failing to support H3.

Study 3 Discussion

Study 3 did not support our hypothesis regarding collaboration vs. risk pooling but was in other ways consistent with the results of studies 1 and 2. Looking first at partner choice decisions, there were significant positive effects of both productivity and generosity, but the effect of generosity was much stronger (as in studies 1 and 2). The effect of productivity on partner choice decisions was not moderated by either sex or condition (failing to support H1 and H3) but was moderated by generosity: Productivity had its strongest effect among

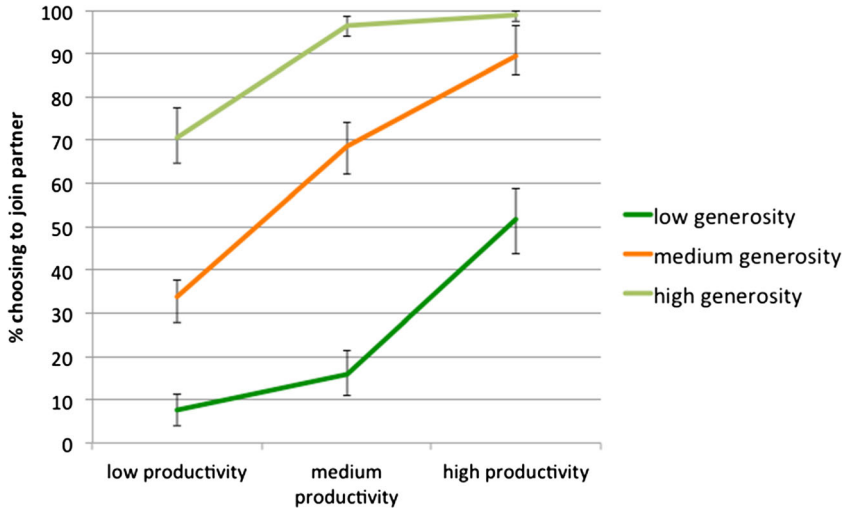

Fig. 6 Effects of productivity and generosity on decisions to join a partner (study 3). *Error bars* are binomial 95% CI based on 1000 bootstrap samples

medium-generosity partners (as in study 2), and going from medium to high productivity had a marked effect among low-generosity partners. Together with the results of study 2, these results suggest that productivity is most important to partner choice decisions when generosity does not provide a clear signal of partner value, and that high productivity can partially restore a stingy partner's value.

Turning to fairness judgments, as in studies 1 and 2, productivity had a significant positive effect and generosity had a much stronger positive effect. The effect of productivity was moderated by sex, such that productivity had a stronger effect on men's fairness judgments than on women's, supporting H1. However, productivity did not matter more to fairness judgments in the collaboration condition (failing to support H3); in fact, generosity had a stronger effect on fairness judgments in the collaboration condition than in the risk-pooling condition, which was unexpected.

General Discussion

Across the three studies, we tested how partner productivity and generosity jointly affect people's choices of cooperative partners and judgments of the fairness of resource divisions. In particular, we sought to illuminate the calibration of the preference for productive cooperative partners, which is a relatively new area in partner choice research (Eisenbruch et al. 2016; Macfarlan and Lyle 2015). Even though our participants were anonymous players in a brief game with real incentives, their behavior cannot be fully explained by the payoff structure of the game. Instead, we observed mixed evidence that participant behavior conformed to the hypothesized demands of an ancestral biological market of long-term cooperative partners, which may indicate the activation of psychological mechanisms specialized for that domain.

Table 2 presents a summary of hypothesis tests. Though results were mixed, several patterns emerge: First, results were stronger for fairness judgments than for partner choice decisions. This may be because fairness was measured continuously, while partner choice decisions were binary. If generosity is the primary criterion for partner choice, then the binary nature of this choice may mask any variations in the relative importance of productivity and generosity, while the continuous nature of the fairness judgments may be more sensitive to these variations.

Second, partner choice decisions and fairness judgments appear to be sensitive to the degree to which productivity is based on skill (and thus reveals the ability to generate benefits in the future), but not to cues of a risk-pooling vs. collaborative relationship. In study 1, the framing manipulation contrasted skill/collaboration with luck/risk pooling; in study 2, the manipulation contrasted skill vs. luck; and in study 3, the framing contrasted collaboration with risk pooling. A productivity by framing condition interaction for fairness judgments was thus found each time that skill vs. luck was part of the manipulation, but was absent in a pure manipulation of collaboration vs. risk pooling. The collaboration vs. risk-pooling manipulation was extremely subtle (see S1.2); future studies may be able to produce an effect of cooperation type

Table 2 Summary of hypothesis tests. "Yes" indicates that a hypothesis was supported; "No" indicates that a hypothesis was not supported

	Study 1	Study 2	Study 3
Fairness judgments			
Productivity × sex	No	Yes	Yes
Productivity × condition	Yes	Yes	No
Partner choice decisions			
Productivity × sex	No	No	No
Productivity × condition	No	Yes	No

using stronger manipulations (discussed below), or it may be the case that partner evaluation heuristics are not calibrated by this variable. Note that the skill vs. luck manipulation is different from past studies that manipulated entitlement to a resource based on either having completing a task vs. receiving the resource as a windfall (e.g., Cherry et al. 2002), or manipulations that allocate a favorable position between two participants based on relative performance on a task (e.g., Fleiß 2015). In our design, all partners completed the foraging task, and all thereby "earned" their productivity level via performance. The only difference between the conditions is the extent to which that performance is revealing of the ability to generate benefits in the future, so our results therefore suggest specialization for long-term cooperative relationships.

Third, men and women show subtle differences in their cooperative partner choices and fairness judgments that suggest evolution in different cooperative domains. In addition to the sex by productivity interactions listed in Table 2, there was a three-way interaction in study 1 such that men's but not women's fairness judgments were more sensitive to productivity among stingy partners, and women's partner choice decisions were more sensitive to generosity than were men's in study 2. The repeated emergence and directional consistency of these sex differences (productivity mattering relatively more to men, generosity mattering relatively more to women) give us moderate confidence in their reliability. We suggest that men place greater weight on partners' productivity due to selection pressures from cooperative large-game hunting and warfare, in which there is wide variance in both outcomes and partner skill.

The integration of productivity and generosity cues to produce partner choice decisions and fairness judgments is also revealing. Generosity consistently had a much larger effect on both partner choice decisions and fairness judgments than productivity did, even though productivity and generosity contributed equally to earnings. In studies 2 and 3, there was a similar interaction between productivity and generosity on partner choice decisions, such that productivity mattered most at medium generosity. Taken together, these patterns suggest sophisticated heuristics for evaluating potential cooperators: When choosing partners, generosity is paramount, with highly generous partners nearly always desired and stingy partners generally avoided. Medium generosity, however, is an ambiguous cue. We suggest that the effect of productivity on a partner's desirability is elevated when their generosity level is neither high enough nor low enough to itself determine their partner value, in order to compensate for the ambiguous generosity cue. This conditional weighting of cooperative partner choice criteria adds nuance to the primacy of warmth-related (vs. competence-related) traits that is typically discussed in the social cognition literature (e.g., Fiske et al. 2007; Wojciszke 2005), and extends Raihani and Barclay's (2016) finding that partner choice decisions may be more sensitive to generosity than wealth.

We propose three speculative, nonexclusive explanations for why generosity has a stronger effect than productivity in our data, and by extension, why warmth matters more than competence in person perception generally (e.g., Fiske et al. 2007; Wojciszke 2005). First, people may vary more in their dispositions toward us (revealed by their generosity) than in their productivity. Dispositions can range from all-consuming love to all-consuming hatred, while there is a narrower range of likely levels of productivity (i.e., most adults are probably at least somewhat productive, but there is likely an upper limit on individual productivity). Insofar as preferences are an evolved response to variance (e.g., McNamara and Leimar 2010), the greater variance in intentions among possible social partners—rather than its greater absolute importance (cf. Fiske et al. 2007)—may have created the stronger preference for generosity. Second, humans cooperate in multiple domains (e.g., hunting, childcare, etc.; Jaeggi et al. 2016). How much somebody cares about a person likely predicts their treatment of that person across cooperative domains (see Tooby and Cosmides 1996), but productivity may be more local to particular domains. Therefore, people may prioritize a partner's generosity because it predicts the flow of benefits across a wider range of situations. Third, risk pooling was overwhelmingly important to ancestral survival (Sugiyama 2004), so it may be the case that the primary concern of social preferences is the identification of people who will be reliable social insurance policies. Because how much a person cares about another individual predicts how likely they will be to provision them in times of need (Tooby and Cosmides 1996), people may prioritize cues of caring in social partner selection. Once the primacy of generosity evolves (for these or other reasons), the expressed preference for generosity may be further enhanced by signaling demands. Prioritizing generosity may signal that one will treat others generously as well, but prioritizing productivity could be seen as socially undesirable.[2]

One limitation of this research pertains to the salience of our manipulated cues. Productivity, generosity, and types of cooperation and productivity (skill vs. luck) were cued by brief, verbal information, but the relevant psychological mechanisms are likely designed to take much richer inputs. Given that most production in the real world likely involves both skill and luck, and most cooperative relationships likely involve elements of both risk pooling and collaboration, sex differences may be subtle and it may take very strong cues to substantially shift people's partner evaluation heuristics. Nonetheless, we chose to provide brief, verbal cues in order to create perfectly independent manipulations of productivity and generosity, and to hold the payoff structure of the game

[2] We thank an anonymous reviewer for this suggestion.

constant across all conditions. Therefore, we view the present results as a well-controlled proof of concept, but a challenge for future research will be to use richer cues of partner value and context (e.g., actual cooperative interactions, social/reputation information, and anthropometric cues of partner value) without confounding cues or altering incentive structures.

Conclusion

The observed cooperative partner choices and (especially) fairness judgments cannot be fully explained by the incentive structure of the present games, but instead appear calibrated for a biological market of long-term cooperative relationships: The preference for generosity was consistently much stronger than that for productivity, but a partner's productivity mattered most at medium generosity; participants were more sensitive to productivity when it was revealing of the future ability to create benefits rather than luck; and men were more reliant on productivity information than were women. Given that most partner choice research has focused on dispositional cooperativeness, these findings on how the preference for partner productivity is calibrated may be an important addition to the literature. We hope that partner choice researchers will give additional attention to productivity and that biological market theory will increasingly inform the study of social cognition more broadly.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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