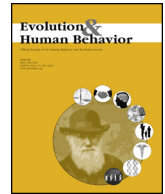




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Paternity confidence and social obligations explain men's allocations to romantic partners in an experimental giving game

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ABSTRACT

Paternal care in humans is facultative, with investment decisions responsive to socioecological context. In particular, paternity confidence is thought to have a significant impact on men's provisioning. However, various aspects of the relationship a man has with his partner can also influence the way he provides for his children. Previous papers have tended to focus either on these kinds of relationship dynamics or on the impact of paternity confidence. However, these categories are often intertwined and parsing their contributions can be conceptually and methodologically difficult. To better understand how paternity confidence and relationship dynamics impact men's investment decisions, we used a series of pictorial vignettes to assess the resource allocation strategies of Himba men. We focus on three traits: mate fidelity, partner type (marital or non-marital), and relationship status (current or former). Results suggest that men prioritize mate fidelity and current reproductive partners in investment decisions, but social obligations to past and current partners and the presence of other male investors also influence decisions. Himba men appear to be balancing social norms related to marriage and fatherhood with individually-driven incentives to invest in current and more faithful partners.

1. Introduction

Human fathers are rare among mammals for the level of care they provide to their mates and offspring. This care, however, is facultative (Geary, 2015), varying depending on their ability to affect offspring fitness, the opportunity costs of allocating energy to parenting over mating effort, and the risks of misallocating investment in extra-pair offspring (Clutton-Brock, 1991; Gray & Anderson, 2010; Trivers, 1972). In addition to these factors, which are typical predictors of paternal care, human fathers face an additional set of decisions related to paternal investment, which appear to be quite rare in other species. Men not only *have* extra-pair mates and offspring, they invest in them. They also invest in spouses and children from previous relationships, for example after a divorce. This means that men are facing three kinds of decisions about how to allocate care: 1) how much to invest in a faithful partner versus an unfaithful one; 2) how much to invest in a formal (marital) versus an informal partner; and 3) how much to invest in a current versus a former partner. In each individual case there is a clear and intuitive prediction (e.g. men should invest more in faithful than unfaithful partners); but investment decisions often occur within a complex social milieu, where these categories are intertwined.

One of the simplest predictions about variation in paternal care is that males will titrate their investment in both mates and offspring based on certainty of paternity (Buss & Schmitt, 1993). However, in both humans and non-humans, the evidence for this is decidedly mixed. Experimental manipulations (Neff, 2003; Sheldon & Ellegren, 1998) and within-individual comparisons (Dixon, Ross, & O'Malley, 1994) provide some of the clearest evidence, showing that males adjust their care based on cues of perceived paternity. Correlational studies of paternal care and paternity certainty provide further evidence across a range of species, including in arthropods (Hunt & Simmons, 2002; Zeh & Smith, 1985), fish (Rios-Cardenas & Webster, 2005), birds (Møller & Birkhead, 1993) and mammals (Huck, Fernandez-Duque, Babb, & Schurr, 2014) but can suffer from methodological shortcomings (Kempnaers & Sheldon, 1997; Sheldon, 2002). More interestingly however, there are numerous cases where males do not reduce their care in the face of uncertainty. For example, across > 50 bird species, it was found that while males do adjust their investment in offspring provisioning, other areas of care such as nest-building and incubation are often unaffected by the rate of extra-pair paternity (Møller & Birkhead, 1993). Another large study looking for trends across taxa found that in order for care to be adjusted, both the cost of caring and

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the risk of nonpaternity must be high (Griffin, Alonzo, & Cornwallis, 2013). Males also provide more help to faithful females (Matysioková & Remeš, 2013). In contrast, in some species where extra-pair mating is frequent, significant male care still occurs (Campbell et al., 2009; Fietz & Dausmann, 2003; Randall et al., 2007). In humans, where paternal resemblance is typically used as a proxy for paternity confidence, some studies show biased investment toward those who look similar (Alvergne, Faurie, & Raymond, 2009; Apicella & Marlowe, 2004), but other studies point to alternative explanations, including a reverse in causal order with more paternal care leading to a greater perception of resemblance (Volk, Darrell-Cheng, & Marini, 2010) or confounding factors (Dolinska, 2013). Men have also been shown in some studies to prefer long-term mates who show greater propensity for being faithful (Minervini & McAndrew, 2006; Mogilski, Wade, & Welling, 2014; Thiessen, Young, & Burroughs, 1993), and to be more upset than women by sexual infidelity, which carries the risk of nonpaternity (Buss, 2018; Scelza et al., 2019).

In humans, cultural institutions and social norms further complicate men's decisions. In particular, the institution of marriage is central to contextualizing men's investment decisions. Marriage formalizes obligations and expectations toward partners and children (Gough, 1959). These obligations persist even in the face of paternity uncertainty, as seen in cultures where social and biological fatherhood are divergent. For example, among polyandrous groups, recognition of social fatherhood is intimately tied to responsibility for a child's welfare, even though the practice of polyandry significantly increases paternity uncertainty (Levine, 1987; Starkweather & Hames, 2012). Similarly, in societies that practice partible paternity, men who are denoted as a child's father are routinely expected to provide resources and protection, despite the possibility that they are not the biological father (Beckerman et al., 1998; Walker, Flinn, & Hill, 2010).

Studies of investment by step-fathers provide another useful comparison. Step-fathers have been shown to contribute significant amounts of direct care and resources toward children with whom they share no genetic relatedness, but to whom they have a socially accepted paternal role (Anderson et al. 1999a and b; Hofferth & Anderson, 2003). While evolutionary anthropologists have attributed this care to mating effort, the formalization of the step-father relationship via marriage and the emotional attachment that comes with lengthy co-residential relationships with a partner's children mean a mix of motivations are likely at play. Framing fatherhood as a biosocial endeavor encapsulates this view (Anderson, 2011; Sheppard, 2018).

At the other end of the spectrum, where a man is the biological father of a child but his social role is limited, he may also provide substantial amounts of care. However, examples of this are much rarer in the literature. Mosuo men, living in traditional matrilineal households, were historically not required to invest in or co-reside with their children (Hua, 2001; Mattison, 2010), and yet these men routinely provide both monetary and direct care, at least in contemporary families (Mattison, Scelza, & Blumenfeld, 2014). Nayar fathers in southern India who were in informal, “visiting” relationships with their children's mothers had few or no social obligations toward their biological children throughout their lives, but were expected to make some contributions, including paying the expenses associated with childbirth (Gough, 1959). Caribbean scholars, in studying the persistent effects of slavery and indentured servitude, have examined the emergence of matrifocal families where men are more marginalized in family life and formal unions are rare, or occur later in life (Brunod & Cook-Darzens, 2002; Gray et al., 2015; Roopnarine, 2013). Biological fathers in these families are not necessarily uninvolved, but their investments tend to be less reliable than those made by husbands, particularly where partnerships are fragile and short-lived (Carlson & McLanahan, 2010; Tach, Mincy, & Edin, 2010).

Finally, there are the cases when marriages break down. It is a common assumption in the evolutionary literature that divorce is equated with the total desertion of parental duties (Blurton Jones,

Nicholas, Marlowe, Hawkes, & O'Connell, 2000; Hurtado & Hill, 1992), often due in part to grouping divorce with other reasons for father absence like death, each of which may affect children differently (Shenk, Starkweather, Kress, & Alam, 2013). However, in many cases, paternal care continues in some capacity after a divorce, and rarely ceases altogether. Systems of alimony and child support formalize, and often mandate, these commitments, but even where they are absent, fathers typically continue to have relationships with their children, and even with their former spouse (Minton & Pasley, 1996). In two parallel studies in Albuquerque and South Africa, Anderson and colleagues show that while divorce or dissolution of formal partnerships may lead to lower levels of direct investment (e.g. spending time, help with school work), after divorce fathers still invest in their children indirectly, by providing money for school, clothing, and other expenditures (Anderson et al., 1999a and b).

When partnerships are informal, their dissolution tends to result in fewer continuing obligations, especially as the years since the partnership ended increase (Lerman, 2010; Ryan, Kalil, & Ziol-Guest, 2008; Tach et al., 2010). However, the extent to which fathers continue to invest in children from informal unions appears to depend in part on the way that these unions are viewed within the community. For example, declines in investment after the union ends, and particularly after a man enters a new union and has additional children, are less precipitous among African-American fathers, who live in communities where non-conjugal unions and out-of-wedlock births are more socially normative, than among whites or Hispanics (Edin, Tach, & Mincy, 2009).

Aside from the status and trajectory of the union itself, it is likely that men are also considering the context surrounding a partnership when making investment decisions. This can include myriad factors, including the wealth of the man and the woman, their degrees of kin support, the number of dependents each has, and so forth. One factor which may be particularly important is the presence of another male provider. In other species, there is evidence that males adjust their care, not only based on factors like paternity certainty, but on the level of care expected from other males (Briskie, Montgomerie, Pöldmaa, & Boag, 1998; Davies & Hatchwell, 1992). Similarly, in humans, we expect that an ex-wife who has remarried will likely be treated differently than one who is single. Similarly, an extra-marital partner who is married and has the support of her husband is in a different position than one who is unmarried and relies on her boyfriend as her primary source of support.

1.1. Study aims and predictions

The complicated nature of men's investment patterns described above makes disentangling the effects of marital status, societal obligations, mate fidelity, and paternity difficult. Here we take an experimental approach to begin to parse these effects. This study was conducted with Himba men living in northwest Namibia. Himba represent an optimal population to conduct this study because it is a culture where concurrent and sequential partnerships are both common, nonpaternity events are frequent, and where notions of social fatherhood are strong (see below for details). We use a multistage vignette questionnaire to understand how competing influences affect men's allocation strategies.

We first test three primary predictions: (1) men will favor faithful over unfaithful partners; (2) men will favor formal over informal partners; (3) men will favor current over former partners. These predictions are not mutually exclusive, and we expect to find support for all of them.

Next, we test predictions derived from three strategies that men could employ in deciding how to allocate their resources. While there is some overlap in what is expected from each strategy, they lead to divergent pictures of men's allocations (Fig. 1).

(a) *Social Obligation Hypothesis*: If societal norms about monogamy

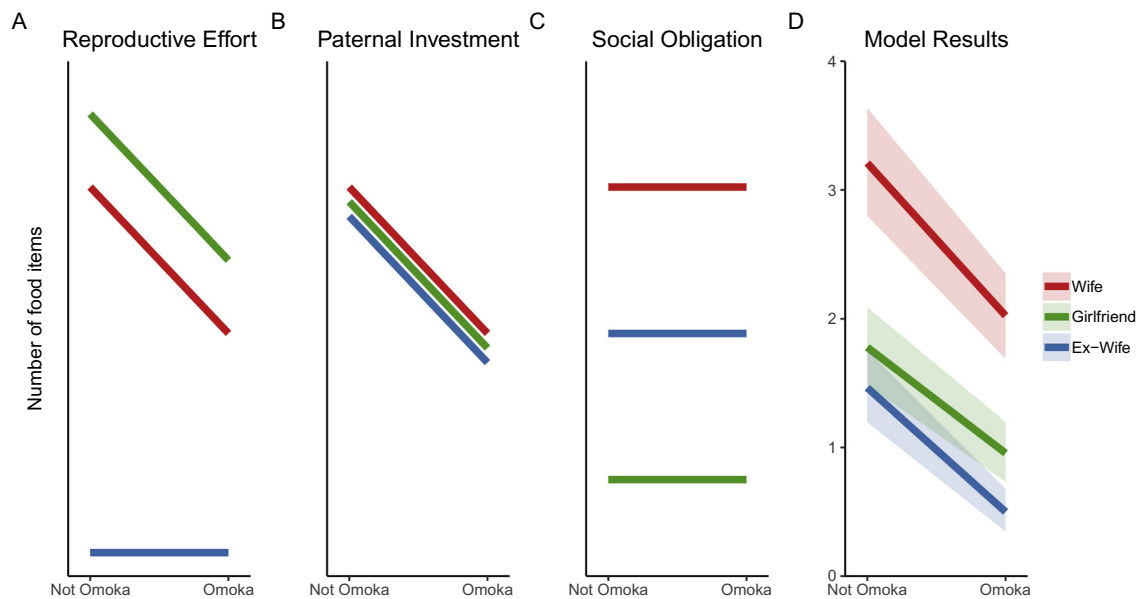


Fig. 1. Predictions and model outcomes for food allocation by partnership category. Panels A, B, and C represent predictions of relative food allocation based on the expectation that Himba men allocate based on reproductive effort, paternal investment, and social obligation respectively. Panel D represents predictions from the best fit model, with shaded areas representing 89% prediction intervals, indicating men allocate goods based on a mix of these different strategies.

and social fatherhood are driving men's investment decisions, we expect formal partnerships (with wives and ex-wives) to take priority over informal partnerships (with girlfriends), with the largest allocations going to current wives. In addition, in line with the idea that men should invest in the children to whom they are the named father, we expect no differences in allocations to biological versus non-biological children.

(b) *Paternal Investment Hypothesis*: If men are motivated primarily by concerns of paternal investment, we expect them to titrate their allocations depending on the biological status of the child. Partners with biological children will be favored over partners with non-biological children across partner types.

(c) *Reproductive Effort Hypothesis*: If men's allocations are driven mainly by the goal of securing as much future paternity as possible, current partners (wives and girlfriends) will be favored over former ones (ex-wives). Among current partners, we expect men to allocate more to informal partners, as there is less certainty that the partnership will continue, and therefore more effort needed for relationship maintenance.

Finally, we address the role of need in men's resource allocations, which may be further complicating the relationship between social norms and mating-parenting trade-offs. When men allocate resources to their partners, they are typically aware of her partnership status (i.e. whether she has a romantic partner other than him), and we expect that this may in part be driving men's decisions about how to invest. Therefore, we predict that when paternity and partner type are equalized, men will favor the partner whose need is greatest. In our study we use the presence of another partner (husband or boyfriend) as a proxy for need.

2. Methods

2.1. Study population

Himba are semi-nomadic agro-pastoralists, living in the Kunene region of Namibia. They are an ethnic minority, closely related to Herero, but with greater reliance on a subsistence-based diet, mainly of milk, meat, and maize (Bollig, 2010). Increasingly, these foods are being supplemented by store-bought items like pasta, rice and sugar,

although they still make up only a small portion of the diet. Electricity and plumbing are absent in the community save for a few community water pumps that provide water for people and livestock, and small solar units. Most adults have cell phones and a small number of men have vehicles. Households are typically polygynous and consist of extended families, ranging in size from 8 to 25 individuals. Marriages are all arranged, though second marriages are typically “love matches”, where the couple choose each other and then get formal permission to marry from their families. Polygyny co-occurs with a high degree of female autonomy, including the ability to divorce, frequent female mobility and strong connections with women and their kin after marriage (Scelza, 2011b, 2015). In the event of a divorce, former spouses often continue to have regular contact, particularly if they co-reside in the same community. It is not uncommon to find ex-spouses visiting each other's households or chatting at a funeral or other social event.

Important to this study, concurrent partnerships are commonplace for both men and women, and numerous cultural norms permit and protect the maintenance of these informal unions (Scelza, 2011a; Scelza & Prall, 2018). Informal partnerships range from brief encounters to lengthy relationships that span the births of multiple children. This practice results in a high rate of extra-pair paternity, with 48% of children born into marriage fathered by someone other than the husband (Scelza et al. in press). Here we refer to children born outside of marriage as *omoka*, one of several terms and phrases used in Otjiherero to describe children born through extra-marital or nonmarital partnerships.

As a result of the high rates of concurrency and extra-pair paternity, Himba clearly distinguish between social and biological fatherhood. The majority of formal norms for provisioning and inheritance emphasize the social father (husband of the child's mother) as the key paternal figure. However, resource transfers between men and their informal partners and children are frequent, and include cash, food, medical fees, and occasionally even livestock. Informal partnerships occur with both unmarried individuals and those who are married to someone else, though the latter is treated with much more secrecy than the former. Both men and women freely discuss these partnerships with same sex individuals, kin, and even on occasion with their spouses. The regularity of extra-marital relationships and the openness with which Himba men and women speak about them facilitated this study as the

vignettes we provided were familiar to most participants.

As is the case generally with pastoralists, men provide little in the way of direct care for young children (Marlowe, 2010; Muller et al., 2008). However, most household wealth is owned by men, and husbands are expected to provide the majority of necessary resources for their wives and children, both through their ownership of subsistence livestock and because they are more likely to have access to cash (from selling livestock), which can be used to purchase supplemental food. Fathers also typically pay brideprice when their sons marry and play an important social role in arranging their children's marriages and making other household decisions that affect child welfare (e.g. decisions about schooling and accessing health facilities). Wealth is passed mainly matrilineally (between brothers and then from uncle to nephew) but there is increasing preference for patrilineality, and fathers are able to pass some livestock to their sons (Scelza et al., 2019). In addition, there is patrilineal inheritance of residences and the ritual and social responsibilities associated with being head of household (Bollig, 2005). These responsibilities fall to the social father (the husband) regardless of the biological status of the child. Himba have strong social norms that men should provide equal care to children, regardless of paternity status, and behavioral data are generally aligned with these views (Prall and Scelza, 2016).

2.2. Procedure

Himba men were opportunistically recruited to participate in this study. Inclusion criteria included being between 16 and 70 years of age and having had at least one long-term romantic relationship. Basic demographic information, including formal and informal partnership status, was collected. The men completed three different resource allocation tasks, conducted in the local language of *Ojijherero*, with the aid of local research assistants. Comments and justifications that the participants offered opportunistically during the tasks were recorded, for use in contextualizing the data. The total study time was about 15 min and participants were compensated with a small gift (e.g. maize, sugar, washing powder). This study received ethical approval from UCLA (#10-000238).

In the first task (Task 1), men were shown six laminated cards depicting colorized images of Himba women and children (Fig. S1). A 3×2 design matched three relationship types (wife, girlfriend, ex-wife) with two child types (biological and not biological). Non-biological children were reported to be fathered by the woman's boyfriend through an extra-marital partnership. Together these led to four possible types of fathers (*pater/genitor*, *pater* only, *genitor* only, neither) and allowed us to look for differences by partner status (former or current) and partner type (formal or informal partner). Each card was described and participants were asked to recall key characteristics as a comprehension check (Fig. S1 includes the text that accompanied each card). Erroneous responses during the comprehension check were corrected and re-tested as needed. Participants were then given ten tokens representing store bought food items, and asked to distribute the tokens across the six cards. The order and number of allocations to each card was recorded. Next, participants were given a single food token, and asked to place it on the card of their choice. The selected card was then removed. This process was then repeated, resulting in an ordered ranking of the 6 cards (results for this task were not substantially different from the 3×2 ranking, therefore results are reported only in supplementary materials).

In the second task (Task 2A), participants were shown two cards (Fig. S2), one representing an informal partner who was unmarried, and the other representing an informal partner who was married. The participant was told that the infant in each picture was their biological child. Participants were given ten tokens representing food items, and asked to allocate these items between the two women. Participants were then told that the child was sick and needed money to go to the clinic, and asked to allocate ten Namibian one-dollar coins

(representing clinic fees) between the two scenarios. Finally, participants were given nine plastic goats, and asked to distribute the goats between the women in the two scenarios. Nine goats were given instead of ten to prevent equal distributions in all cases.

Finally, participants were shown two new cards (Fig. S3), one representing a wife with no other partner, and the other representing a wife with a boyfriend (Task 2B). Again both images had children, and the participant was told both were his biological offspring. Participants were then asked to allocate food tokens, clinic money, and goats as in Task 2A.

A total of 43 men, with a mean age of 34.4 years (range 18–71) completed all three tasks. A majority of respondents were married (62.8%) and reported having at least one informal partner (79.5%). Seventy-three percent of men had at least one child.

2.3. Analysis

Allocation results from Task 1 were first compared using the repeated measures ANOVA function as part of the BayesFactor package (Morey, Rouder, & Jamil, 2015) using default priors, where resulting factors can be interpreted as the strength of the evidence for the alternative hypothesis (see Jarosz & Wiley, 2014). To test the three hypotheses described above, men's allocations in task 1 ($n = 258$ allocations from 43 men) were analyzed using a series of Bayesian Poisson regression models using the *rethinking* package (McElreath, 2013 2018). Binary predictors (formal vs informal, omoka vs non-omoka, and current vs former) were added sequentially to assess the impact of each predictor on model fit (Models 1–3). Next, models including two of the predictors were created (Models 4–6), along with a final model that included all three predictors (Model 7). Because the total number of food items that could be allocated was fixed for all participants, varying intercepts by participants were not included in the model, and all observations are assumed independent. Alternate multilevel modeling approaches, which include varying intercept by participant and partner category yield similar results. Multilevel approaches were also used to assess the impact of participant age and marital status, but effects did not deviate meaningfully from zero (Fig. S7). To compare the seven models described above, the Widely Applicable Information Criterion (WAIC) was used to assess predictive accuracy (Table 1). Akaike weights using WAIC values show the conditional probability of each model. Models with greater weight have a higher probability of fitting the data, relative to the other models being compared (Wagenmakers & Farrell, 2004). To assess comparisons between categories in Tasks 2A and 2B, a paired test was conducted, again using the BayesFactor package.

Table 1
Model comparison results.

Model	Partner Fidelity ^a	Relationship Status ^b	Relationship Type ^c	WAIC	Weight
Null				802.6	0
1	✓			764.3	0
2		✓		765.2	0
3			✓	797.6	0
4	✓	✓		723.1	0
5	✓		✓	758.6	0
6		✓	✓	730.2	0
7	✓	✓	✓	689.0	1

^a Paternity refers to the stated paternity of the child in the vignette (non-biological children are referred to as *omoka*).

^b Relationship status compares those vignettes where the man is currently married to those where he is divorced.

^c Relationship type compares vignettes where the partner in the scenario is a formal partner (wife) versus an informal one (girlfriend).

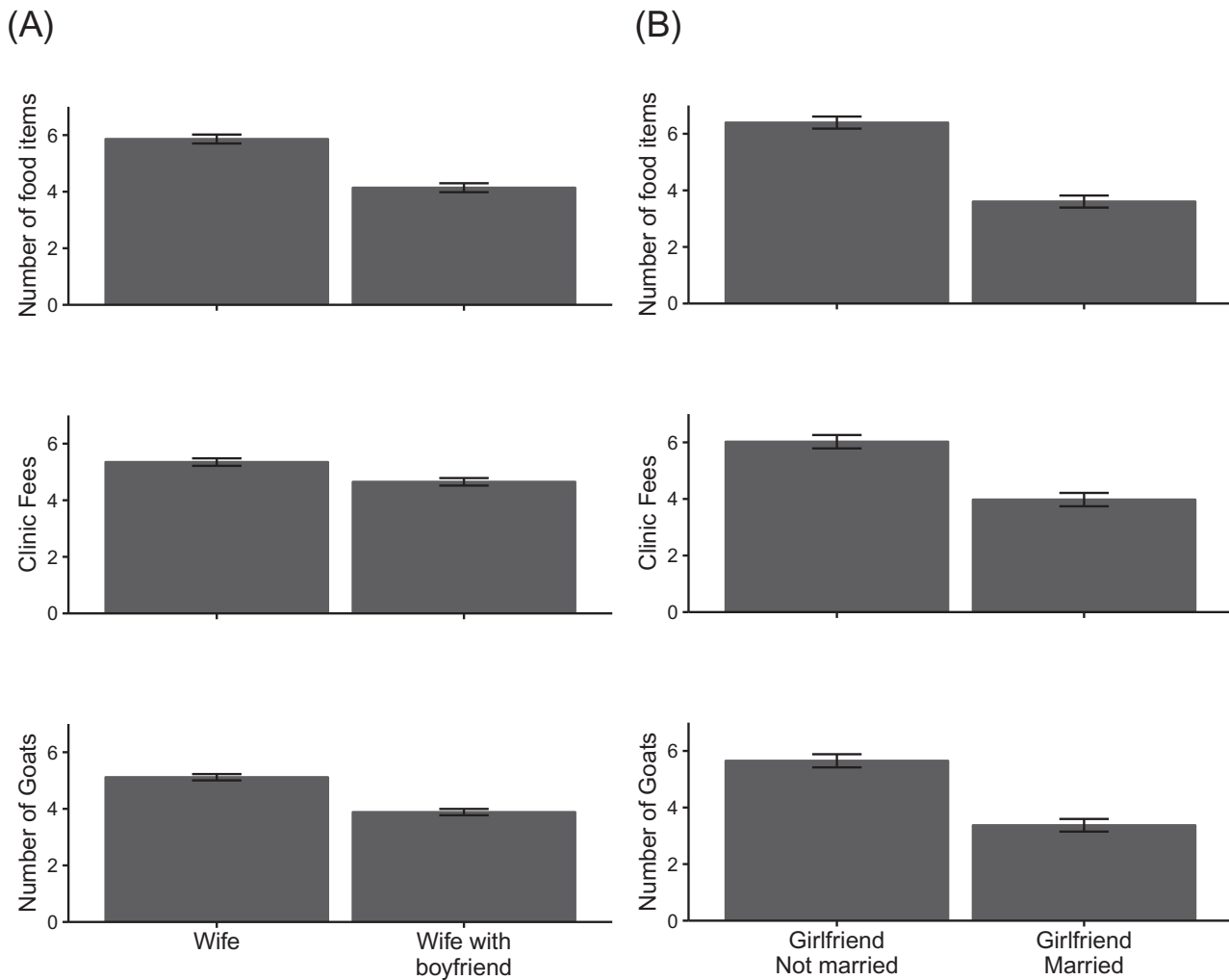


Fig. 2. Mean (and standard error) for allocation in task 2a and 2b.

3. Results

3.1. Task 1: - food allocation

Bayes factor comparison of categories reveals differences in the allocation of food tokens between categories ($BF > 100$). Wives were allocated the most food tokens, and women with biological children (non-*omoka*) received more than women with non-biological children (*omoka*) (Fig. S4). Comparison of models with single predictors (Models 1–3) indicate that the partner fidelity model yields the best fit, followed closely by the relationship status model. When multiple predictors were included, models that include relationship status result in the lowest WAICs (indicating better fit), while the best fit model overall includes all three predictors and relevant interaction effects. Posterior predictions of the best fit model are shown in Fig. 1 panel D.

3.2. Task 2A - informal partner allocations

Mean allocation of food items, clinic fees, and goats are shown in Fig. 2. Using pairwise Bayes factor tests, unmarried girlfriends are allocated more resources than are married girlfriends ($BF > 100$). When they had the chance to divide resources equally (for food and clinic fees), men did so 18.6% of the time with food distributions and 41.9% of the time when dividing clinic fees. In the unequal distribution task (goats), men gave more to the unmarried girlfriend 90.7% of the time.

3.3. Task 2B - formal partner allocations

Wives without boyfriends tended to receive more resources compared to wives with boyfriends (Fig. 2). Pairwise Bayes factor comparison indicates strong differences for both food and gifts ($BF > 100$). However, there is little difference in the allocation of clinic fees between wives with and without boyfriends ($BF = 3.43$). Among the tasks where an equal distribution was possible, men did so 39.5% of the time for food and 81.4% of the time for clinic fees. When dividing the nine goats, men gave more to the wife without a boyfriend 90.7% of the time.

4. Discussion

Our results show strong evidence for our primary predictions, which are derived from life history theory, and which are fairly intuitive. Fig. 3 demonstrates this most clearly. All else equal, men favor more faithful partners (rows 1, 10, 15), partners they have formal unions with (2, 7) and, to a lesser extent, current partners (4, 9, 11, 14). Our secondary predictions, which bring these factors together into a series of potential strategies, show greatest support for the paternal investment hypothesis, as partners with *omoka* children are consistently short-changed in the allocations, and the social obligation hypothesis, as wives are strongly favored over other types of partners (Fig. 1, Panel D). The best fitting model included all three primary factors: partner fidelity, relationship type and relationship status, providing additional

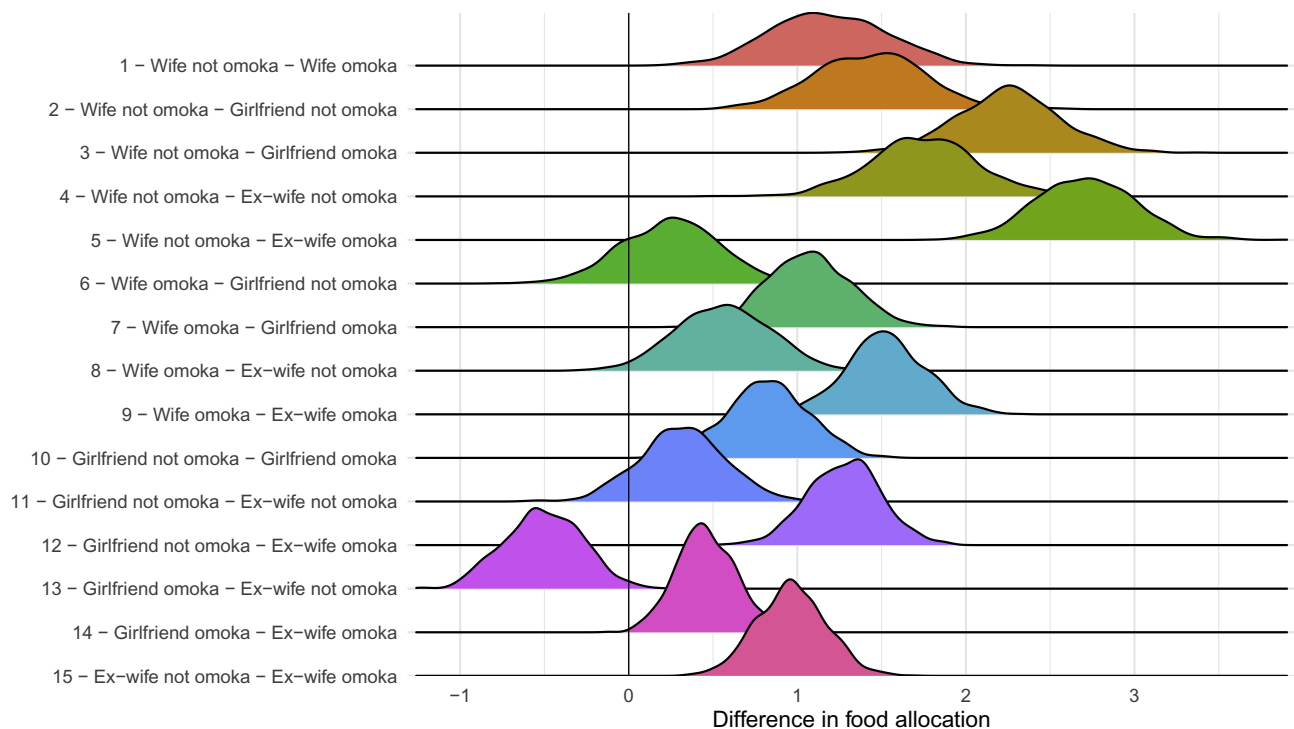


Fig. 3. Posterior predictions of differences between categories from the best fit model predicting food allocation. Each distribution represents the difference between the two types of women, so that distributions to the right of zero indicate the first woman listed is predicted to receive more food gifts.

evidence that men are employing a mixed-strategy. These experimental results emphasizing a mixed strategy are aligned with behavioral data on Himba paternal investment (Prall and Scelza, 2016). Measures of children's nutritional status, fosterage status and livestock transfers show some titration of investment toward children men believe to be omoka, but these occur largely when investments occur in the more private household domain. When investments occur in more public domains, social obligations to wives and marital offspring lead men to treat biological and non-biological children more equally.

The best fitting model shows that overall girlfriends and ex-wives are treated relatively equally (Fig. 1, Panel D), but this finding masks some of the interesting variation that occurs in distributions to these two partner types (Fig. 3). In the two cases where *omoka* status differs between girlfriends and ex-wives (rows 12 and 13), men allocate substantially more to the partner with his biological child. Paternal investment appears to be a greater motivator than either social obligations or mating effort. Similarly, when the child is not *omoka* in both cases, distributions to girlfriends and ex-wives are indistinguishable (row 11). Where we see a breakdown is in the scenario where both children are *omoka*. Here we see men favor girlfriends over ex-wives, suggesting some support for mating effort over social obligation (row 14).

The second part of our study was designed to understand whether men are titrating their allocations dependent on whether another partner (and potential provider) is present. Men's allocations to girlfriends fit this pattern, with substantially greater giving to girlfriends who are unmarried than to those who are married. There are several explanations that could account for these results, other than the need-based explanation we are positing. Men could give less to women with other partners as a form of punishment for their infidelity. Women without other partners may also be more likely to father a man's next child, so that giving more to her represents mating effort. Our data do not allow us to test between these explanations. However, opportunistic quotes recorded during the interview process invoking differential need were frequent among our participants. In a typical iteration, one man stated, "This woman has a husband. I will help this one because she

doesn't have a husband and needs support." Therefore, we conclude that need-based considerations are likely to be one important factor in men's decision-making.

A slightly different pattern emerges in Task 2B where men made allocations across wives. Those without boyfriends still received more than those with boyfriends, but the results were less consistent. Men were much more likely to distribute resources evenly across wives than across girlfriends. In the two categories where men were distributing an even number of items (for food and clinic fees) they divided them equally between wives, 40% and 81% of the time respectively, compared to only 19% and 42% of the time with girlfriends. One man reported, "I think of them as my co-wives. You have to treat them equally so that they don't get jealous and one doesn't think that I don't like her." In the third iteration of Task 2, men were forced to make an unequal distribution. Unlike with girlfriends, where this did not pose a problem, some men were very resistant to making a choice between their wives, with one commenting "I would cut that goat in half" rather than have to choose. This again speaks to the complex interaction of factors affecting men's strategies. Social obligation may dictate that men should treat their wives (relatively) equally, but men may also be hedging their bets, keeping both wives happy may increase their overall chance of paternity in future children.

We also surmise that need was not driving men's choices in the wife scenario to the same degree that it was with informal partners. Opportunistic comments did not stress support from another partner in the way they did in the girlfriend comparison. This may be due to the difference in obligatory provisioning that exists between formal and informal partners. While a man is obligated to provide for his wives, giving to girlfriends is voluntary. Previously, our work showed that for this reason, women had a stronger preference for generosity in boyfriends, whereas in husbands, wealth mattered more (Scelza & Prall, 2018). Here we see that men bias their giving to girlfriends based on need, but factoring in the gifts of others to their wives seems secondary to concerns about keeping the peace at home and treating wives equally.

4.1. Limitations and future directions

The experimental approach used here provides some insight as to how Himba men make decisions about allocating resources across partners of different types. While the high rates of concurrency and nonpaternity in this population mean that most men encounter these types of decisions at some point in their lives, rarely would they encounter all of them at once, highlighting an advantage of the vignette approach. However, as with all studies that use hypothetical allocations, these data may not reflect the ways that men divvy up real resources, but rather how they view social expectations to allocate resources. In response to this, many economic games use cash and follow through with distributions as promised in the game; however, this approach was not feasible here. Despite this limitation, we found that the men in our study understood the complexity of the problem before them, as highlighted by opportunistic comments made throughout the task.

In addition while we thought it was important to address the ways in which men's allocations could be altered by the presence of other providers, this is neither the only nor necessarily the most important way that need might influence giving patterns. Other factors we did not consider in this study include the relative wealth or security of the woman herself, the wealth of her parents, and her number of dependents. Similarly, we did not look at how men's own wealth or security affect his provisioning strategy. Finally, while we did not detect any effects of age or marital status in our analyses (see Fig. S7), it is possible this is due to small sample size. Future studies with larger numbers of participants could address these shortcomings, using either behavioral or experimental data.

Finally, this paper focuses exclusively on men's provisioning decisions. The emphasis on men's care as facultative in the literature drove the design of this study. However, while certain aspects of maternal care are obligate in humans (most significantly pregnancy), most care by mothers is quite variable. Future work should consider how the factors studied here impact maternal provisioning decisions.

5. Conclusion

Understanding the facultative nature of paternal investment in humans requires considering not only the dyadic relationship between father and child, but also the relationship between the father and the mother of that child. As Carolyn Bledsoe wrote, “Because children are symbols of links between adults, resource allocations to children, like the performance of sexual or domestic duties, become barometers of adult relations,” (Bledsoe, 1995, 131). Here we evaluate the impact of predictions from evolutionary theory within a particular context of norms and obligations. We show that while men's strategies reflect many of the core principles of life history theory, they are tempered by aspects of the social system, particularly differences in duties and obligations to marital versus non-marital partners. Men also appear to be factoring in the investments of other male partners, motivating them to allocate more to partners whose need is greater. Overall, these data support the view that men's investment is facultative, but highlights the complex nature of the socioecological environment triggering those facultative responses.

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Data availability

Data and code for this project can be found at: <https://osf.io/8bp5z/>

Appendix A. Supplementary materials

Supplementary materials for this article can be found online at <https://doi.org/10.1016/j.evolhumbehav.2019.10.007>.

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