Experimental evidence for time preference among Mikea forager-farmers: Implications for subsistence transitions and conservation planning[1]

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Abstract

We explore whether experimentally-measured time preference explains how rural decision-makers cope with externally-induced subsistence transitions. Mikea of Madagascar maintain diversified portfolios of foraging, herding, farming, and marketing activities. In 2002 conservation organizations succeeded in halting one of the most significant activities, slash-and-burn maize cultivation. They promoted manioc farming instead, assuming that because manioc yields are greater than maize yields, manioc will be judged a suitable alternative. Yet maize matures 3 months after planting while manioc is harvested after a 7-14 month delay. If Mikea discount future rewards sharply, they may prefer maize. A simple choice experiment revealed discount rates and narrative statements from Mikea who planned to cope with the end of maize by specializing in manioc farming versus those who planned to specialize in hunting-and-gathering. The latter sample discounted the future at significantly greater rates than the former, at rates sufficient that some may prefer maize. We conclude that simple economic experiments may assist conservation and development planners in offering alternatives likely to gain local acceptance.

Introduction

Woodburn (1980, 1988) has suggested that some hunter-gatherers value time, manifested in the delay preceding an economic payoff, differently than do other foragers and all farmers and herders. Hunter-gatherers such as Hadza of Tanzania or Ju/'hoansi San of Botswana practice an "immediate return" economic system in which each day's work digging tubers, collecting nuts, or hunting game is rewarded that day or soon after with food (assuming the work is successful). Other groups practice a "delayed return" economic system, in which they must wait for the rewards of their labor. Delayed return foragers spend time preparing nets and traps or tinkering with the growth and reproduction of wild plants with payoffs occurring days, weeks, or months later. Cultivators wait several months to several years from planting until harvest. Herders may care for animals for years, decades, or generations until slaughter or sale (all the while enjoying the immediate returns of milk, blood, wool, and manure).

Woodburn's classification suggests that practitioners of different subsistence economies differ by what economists and psychologists call time preference, also called patience (Godoy et al. 2004) or self-control (Green et al. 1981). Time preference refers to how a decision-maker subjectively judges the tradeoff between reward amount and delay-to-reward, between a smaller payoff available soon versus a larger one later. Decision-makers tend to devalue rewards for which they must wait so that the value of a future reward is discounted in the present (for reviews see Frederick et al. 2003; Tucker 2006).

If time preference helps explain subsistence diversity, it may also be significant in explaining subsistence transitions. Tucker (2006) has used time preference to explain why some some forager-horticulturalists know about intensive agriculture but do not choose to practice it: they discount future harvests sufficiently that they prefer the immediate gains from foraging rather than the delayed advantages of investing additional agricultural labor. Alvard and Kuznar (2001) have used future discounting concepts to explain the transition from hunting to herding. They predict that small-bodied prey reproduce sufficiently fast so that their present (hunted) value may be surpassed by deferred, future value should they be conserved and inherited. Time preference may similarly explain how rural subsistence decision-makers will react to externally-imposed changes in their economies, such as whether they will adopt new subsistence activities in place of those judged environmentally-destructive by conservationists (Tucker in press).

Here we present the results of an attempt to experimentally measure time preference in a diversified economy as it experiences a subsistence transition. Mikea self-identify as hunter-gatherers of the tropical, dry, mixed deciduous-euphorb-xerophytic forest called *Alamikea*, the Mikea Forest (Yount et al. 2001; Tucker 2003). Despite their hunter-gatherer identity, all Mikea households combine foraging for tubers, honey, and small game with lake and marine fishing, maize and manioc cultivation, cattle and goat herding, wage labor, and market trading activities.

Ellis (2000) argues that a household's diversified subsistence portfolio is its primary means for coping with external trends and shocks. Mikea have adjusted their portfolios to cope with new constraints and opportunities throughout their history. Oral histories recount that the first Mikea were herders who coped with the raids and tribute demands of local kings by specializing in foraging and forest life during the 18th and 19th centuries (Tucker 2003). Subsequent transitions resulted from the near extinction of large game (feral cattle and bushpig, *Potamochorus larvatus*) and the introduction of New World crops (maize, manioc, sweet potatoes). In the 20th century Mikea coped with French colonial policies of forced relocation, taxation, and mandatory labor by either cooperating, thus orienting their subsistence portfolios to agriculture; or by resisting and retiring deeper into the forest to increase specialization in foraging. With the introduction of the market economy people shifted their portfolios to take advantage of new cash income opportunities. The early 1980s saw a market boom for maize grown in environmentally-destructive slash-and-burn fields, for sale to international exporters.

The latest subsistence transition is ongoing, as conservation groups seek to establish a protected area or national park in the Mikea Forest. These efforts began with the enforcement of a ban on slash-and-burn maize cultivation in 2002 by a *Commission Mixte* that included the Worldwide Fund for Nature (WWF), Conservation International (CI), Madagascar's *Office National pour l'Environnement* (ONE) and several of its constituent organizations, working with the Malagasy military, gendarmerie, and tribunal system. The World Bank has since offered funds to create a Mikea Forest National Park. As an alternative to maize cultivation, these organizations have advocated cultivation of manioc in the leftover swidden clearings. Manioc yields in the savanna are 8 to 18 times greater than maize, so it is assumed that Mikea will judge manioc to be an appropriate, preferable substitute. Yet one key difference between maize and manioc is the delay to harvest. Maize matures three months after planting, while manioc is left to mature for 7 to 14 months. If Mikea have a strong preference for immediate rewards, the higher payoffs of manioc may be subjectively discounted to below the more immediate value of maize so that maize is preferred.

Choice experiments were conducted with Mikea men and women in 2003 and 2004 at a time when households were deciding how to cope with the elimination of slash-and-burn maize from their portfolios. The independent variable is the informant's stated plan to increase specialization in foraging versus to increase specialization in manioc farming. Quantitative results indicate a significant difference in time preference among the two classes of respondents, with foragers discounting delayed rewards at a significantly greater rate than farmers. Preferences appear to play a role in predicting or explaining how individuals and households cope with change.

Experimental design

The main objective of two brief field seasons in September-October 2003 and in August 2004 was to field-test choice experiment methods for measuring time and risk preference among Mikea. This paper discusses the first experimental attempt. The goal was to simulate the intertemporal choice involved in the decision to forage versus to plant crops with differing delays to harvest. Rewards were scaled to mimic agricultural payoffs (hypothetical 100 kg gunnysacks of maize) and delays stated in months. The experiment used a titration method similar to Henrich and McElreath's (2002) risk preference experiments. It consisted of three trials with three questions each, where each question was a binary choice between 1 sack available now versus X sacks after a trial-specific delay of 6 months, 1 month, or 12 months.

A decision tree for the first trial is presented in Figure 1. The goal is to find the indifference value, a number of sacks at a specific delay for which the participant judges the value of the immediate and delayed options to be equal. The first question was, "which would you prefer: one sack of maize now, or 12 sacks of maize after six months?" If the respondent prefers one sack now, it would take some quantity greater than 12 sacks for her to tolerate a six-month delay. The second question then asks whether she prefers 1 sack now or 24 sacks after six months. Should she chose the 24 sacks, then her indifference value is greater than 12 but less than 24. The third question narrows the range, by asking her to choose between 1 sack now versus 18 sacks after six months. If she chooses the 1 sack now, her indifference value is localized to the 12 to 18 range. The second and third trials were identical except for the delay (1 month, 12 months).

Mikea volunteers were recruited from the forest camps of Belo and Bedo and the villages of Vorehe, Ankindranoke, Ihotre, Namonte, and Ankililale. Each participant received a courtesy gift of 1000 Malagasy francs, equivalent to the value of four cups of coffee. Participants were interviewed in private, although sometimes a close associate or family member was also present. Before the experiment proper, we asked which strategy they would employ following the ban on maize horticulture: increased reliance on foraging or increased reliance on farming?

The experiment had some unintended results. Of the 81 adult men and women interviewed, only 33 took time to consider each question separately and responded to each with a separate value judgment. The other 48 respondents treated the exercise in an abstract, philosophical manner. They responded to all questions without reflection with the same answer—either always choosing the immediate option or always choosing the delayed option—and justified their answers with a narrative statement about why they (or people generally) should or should not be patient. Economists almost universally insist that experiments offer real rewards (Camerer and Hogarth 1999; Hertwig and Ortmann 2001), and we feel sure that had we done so, more participants would have provided the quantitative judgments we expected. Yet the narratives provide a meaningful folk perspective on intertemporal choice, and so are examined here.

Quantitative results

Of the 33 respondents who evaluated each binary choice separately, 4 provided inconsistent answers, for example claiming that it was easier to wait 6 months than 1 month for a reward. These cases are excluded from analysis. Of the 29 usable cases, 10 stated plans to specialize in foraging, 17 planned to become manioc farmers, and another 2 planned to rely on market activities, particularly selling snacks and retailing food items. The forager sample included 4 women and 6 men; the farmer sample consisted of 4 women and 13 men; and the two marketers were women.

Analyses employ the hyperbolic discounting model (Mazur 1987). Given a reward with an immediate value A, for any delay $D > 0$ the reward value is subjectively discounted. The discounted value v_d for a given delay D is:

$$v_d = A/(1 + kD). \qquad (1)$$

The goal of analysis is to calculate the discount rate *k*, the metric by which time preference is measured and compared across samples and populations. A small *k* value indicates that time has little effect on value; at $k = 0$, there is no discounting ($v_d = A$). Larger values of *k* indicate that future rewards are judged to be increasingly grim prospects compared to immediate rewards. We calculate *k* based on the indifference values (v_i) revealed in the experiment.

$$v_i = A(1 + kD). \tag{2}$$

Hyperbolic discounting asserts that indifference values increase linearly as a function of delay.

We calculated *k* for the entire data set and then for the forager and farmer subsets specifically by first pooling individual indifference values at each trial-specific delay and then estimating the median discount rate for the distributions. Because Eq. (2) insists that the indifference values scale linearly with delay, the distribution of responses at each delay should have the same functional form. A given test value k^* of the discounting rate determines test indifference values $A(1 + k^*D)$ for each of the three delays. The estimated median value of *k* is the value of k^* such that half of the responses are above the corresponding test values and half are below. While this procedure does not always determine a single value, it nevertheless specifies a narrow range of median *k* values.

A bootstrap procedure (Efron and Tibshirani 1991; Chernick 1999) is used to establish confidence intervals around each *k* estimate. A bootstrap procedure resamples data with replacement, thereby simulating many realizations of the experiment, where each resample has the same size as the original set. Our calculation resamples 10,000 times, calculating a new median *k* value for each iteration with the procedure described above. Rather than resample individual indifference values that are not strictly independent, we resample individual respondents, each of whom has three indifference values (one per trial). The bootstrap distributions were skewed, and the original dataset was relatively small. To ensure the accuracy of the confidence intervals, we iterated the bootstrap procedure (Martin 1990; Lee and Young 1999). We resampled each of the 10,000 iterations described above 2000 times, sufficient for reliable numerical results (Booth and Hall 1994), to "calibrate" the coverage of the bootstrap confidence intervals. The actual corrections due to this procedure were minimal.

The results are as follows. The median discount rate for all 29 individuals is 2.0/month, with 95% confidence intervals of 1.3-2.8. The median discount rate for foragers, 3.9/month (95% CI = 1.7–7.9), is greater than that of farmers, 1.4/month (95% CI = 0.4-2.5). Because the two confidence intervals overlap it is not obvious whether the two rates are significantly different. A more precise and powerful test is to consider the difference statistic of the forager and farmer medians. A one-sided, 95% confidence interval for the difference in median k values between foragers and farmers is 0.09-∞, indicating that the statistical significance of a null value is well over 95%. Thus we conclude that the median discount rate for foragers is significantly larger than the median rate for farmers.

We also tested for sex differences in time preference using the double bootstrap method described above (women: N = 10; median = 1.6/month, 95% CI = 0.6-2.6; men: N = 19, median = 2.0/month, 95% CI = 1.0-4.6). A one-sided 95% confidence interval in median k values for men versus women is -0.13-∞, indicating no significant difference.

Qualitative results

Of the 48 respondents who provided philosophical responses, 33 explained their choice with one of 12 narrative statements, listed in Table 1.

Most frequently, people explained their tolerance for delay by discussing their needs (N=20), for a durable food supply, to feed children, to meet kin responsibilities, and to counter poverty and hunger. Need was equally likely to be cited by those who always chose the immediate reward as by those who always chose the delayed reward, suggesting that Mikea perceive need to drive both impulsive and patient choices. Both future foragers and future farmers cited need in similar proportions.

The second most common category of explanations were those based on identity or occupation (N=8), including the statement that farmers are accustomed to waiting, and that Mikea live day-to-day. Five people explained that foraging actually made waiting for larger rewards easier and more preferable.

The remaining responses fall into two categories. The more common was vividness (N = 4), particularly the almost proverbial statement "I prefer what my eye can see." The final category was age (N = 1). An old woman stated that she might be dead before delayed rewards arrive.

Proverbs are a significant narrative form throughout Madagascar. In addition to the explanations just presented, informants mentioned proverbs such as "the distant *Cedrelopsis grevei* tree [source of medicine] is no cure," an injunction to take immediate rewards; and "what the goat nibbles is quickly gone," advice to wait for larger rewards.

Interestingly, self-declared future foragers more often chose the delayed option and defended the virtues of patience (15 out of 24) while the future farmers more often chose the one sack now and defended the value of immediate rewards (14 out of 23).[2] While these frequencies are statistically similar ($df = 1$, $\chi^2 = 2.567$, $p = 0.109$), the contrast with the quantitative finding that foragers discount the future more than farmers is intriguing. When speaking hypothetically, foragers recognized the value of large delayed rewards, especially since foraging meets their daily needs throughout the delay. Likewise, farmers recognize of the value of immediate rewards, to meet their needs until harvest.

Methodological significance

This study unexpectedly yielded two forms of data—judgments of the value of specific rewards and delays (as intended), and narrative folk explanations for why one should prefer immediate versus delayed rewards. Both forms of data are valuable for their own purposes, but researchers should employ specific methods to obtain each. To acquire quantitative value judgments researchers may benefit from real experimental rewards. In a comparison of studies with different incentive sizes, Camerer and Hogarth (1999) conclude that for choice experiments, when stakes are low subjects tend to make the choices they believe they are expected to make, by the researcher or society, whereas somewhat larger stakes encourage economistic reasoning. The second form of data may be better acquired through Participatory Rural Appraisal methods (Chambers 1994a,b).

Outside of the controlled environment of a choice experiment, informants are unlikely to describe their cognitive evaluative processes accurately. Nisbett and Wilson (1967) have argued that people's self-reported explanations for their reasoning in psychology experiments typically misidentify stimuli, responses, and the value judgments implied by their choices. Yet people's explanations for their behavior are consistent among participants, suggesting that narratives are socially learned and culturally-salient.

Significance for subsistence transitions

The quantitative analysis presented here suggests that among Mikea experiencing a subsistence transition, those who chose to increase specialization in foraging discounted the future at significantly higher rates than those who chose farming. Yet in their own narratives, the future foragers were equally aware of the value of long-term payoffs, for they could meet immediate needs through foraging while they wait. Likewise, farmers recognized the value of immediate gains to hold them over until harvest time. These findings confirm Woodburn's basic thesis while suggesting that the main concern of people in delayed returns economies may be meeting immediate needs, while those in immediate returns economies dream of future payoffs.

If variation in time preference predicts people's choices during a subsistence transition, what determines an individual's time preference in the first place? Researchers share the same intuition as Mikea, offering explanations involving need, vividness, and age among other factors. Preferences have long been argued to be a function of needs relative to wealth status (Bernoulli 1954[1738]; Friedman and Savage 1948). Becker and Mulligan (1997) argue that wealth influences time preference because wealth may be spent on "future-oriented capital," resources spent making the future seem more vivid. Variables such as age, education, health, and visits to the elderly are also expected to increase the vividness of future rewards and decrease discount rates. Other researchers have likened delayed rewards to a form of incertainty (Rachlin et al. 1991; Green and Myerson 1996), for misfortunes may prevent future payoffs from occurring.

Evidence for the determinants of time preference is mixed. In the only major ethnographic study of time preference, Godoy and colleagues (Godoy et al. 2004; Kirby et al. 2002) found that among Tsimane forager-horticulturalists of Bolivia, discount rates increase with age and education, but are not predicted by wealth or nutritional status. In a study of time preference among Indian peasants, Pender (1996) found that wealthier individuals discount the future at lower rates. Working with western subjects, Kirby and Hernnstein (1995) found that discount rates decrease with increasing age, and Kirby and Maracovic (1996) found that males discount at a higher rate than females.

Some recent studies have argued that preferences are socially-learned, much as narratives appear to be. Social learning refers to decisions made by copying others and conforming to group norms and expectations (Boyd and Richerson 1985; Henrich and McElreath 2003). Social learning may be prevalent because it is easier and potentially more reliable than individual memory, perception, and evaluation. In studies comparing risk preferences across four societies (Henrich and McElreath 2002) and social preferences[3] in 15 societies (Henrich et al. 2004), individual-level variables such as wealth, age, sex, and education did not predict preferences. The authors concluded that the best predictor was social identity itself, suggesting that participants learn preferences from their cultural confederates.

Southwestern Madagascar may prove an interesting field site in which to investigate the causal salience of individual and social variables for determining time preference. There are three identity groups in the region, sharing history, clan memberships, and genealogical and commercial ties. The three identities differ by purported norms of subsistence specialization—Mikea as foragers, Masikoro as agropastoralists, and Vezo as marine fishers—but in practice, most household portfolios are diversified. If preferences are the result of individual perception and evaluation, then preferences ought to vary primarily at the individual level, and be predicted by need or vividness variables, regardless of social memberships. If preferences are socially learned, then members of the same village or social identity should share preferences. This will be tested in future research.

Significance for conservation and development planning

Given the discount rates revealed by this experiment, are Mikea likely to accept manioc as a replacement for slash-and-burn maize?

Mikea plant maize and manioc around the same time in December, during the first days of the rainy season. Maize matures three months after planting. Our field team visited 247 slash-and-burn maize fields in 1998 and 1999 and measured an average yield of 931 kg/ha. Manioc may be harvested at any time from 3 to 20 or more months after planting, with tubers growing larger the longer they are left unexcavated. In 154 fields surveyed in 1999 and 2004, growing times ranged from 7 to 14 months with a mean age of 10.2 months, while yield averaged 17,810 kg/ha. When these values are compared in a hyperbolic discounting model with *k* = 3.9/month, manioc is clearly the superior choice.

But manioc in southwestern Madagascar is more labor-intensive than maize, with yield responding to frequency of weeding. The majority of the fields in our manioc dataset belonged to neighboring Masikoro farmers who weeded two or three times yielding 16,928 to 18,354 kg/ha on average. Mikea manioc farmers typically weed only once (before planting) and experience an average yield of 8,267 kg/ha. A manioc field weeded once represents a similar labor investment to a slash-and-burn maize field. Also, maize has a higher caloric value than manioc, 3640 kcal/kg versus 1490 kcal/kg, respectively (Wu Leung 1968:12, 34). For the same investment of labor, one hectare of maize produces an average of 3,388,840 kcals, while one hectare of manioc yields 12,317,830 kcals.

Figure 2 displays the discounted value functions for these two rewards after appropriate delays (90 days for maize, 311 days for manioc), assuming hyperbolic discounting and using the median discount rates revealed in the Mikea experiment. For contrast, the graph also displays imaginary discount functions for peasants in India, using the midpoint of the discount rates revealed in Pender's (1996) experiments.[4]

On day 1, all three rates predict preference for manioc. At the midpoint rate that farmers in India discount the future, manioc is always judged to be of superior value. At the median discount rates revealed for Mikea, preference switches to maize after a span of days. Preference switching was once thought to be an artifact of the hyperbolic model, but experimental subjects can be induced to switch preference by increasing delay (Green et al. 1994; Kirby and Hernnstein 1995). As *k* decreases, the contrast between starting values increases, and the crossover point occurs later in time. Mikea who plan to specialize in agriculture (k = 1.4/month) would switch preference on day 30. For Mikea who prefer foraging (*k* = 3.9/month), the initial values of maize and manioc are nearly indistinguishable, and preference switches after 15 days, with maize then increasing rapidly in value.[5] Thus for most of the delay preceding the maize harvest, Mikea are likely to prefer maize to manioc. Indian peasants would embrace the transition from maize to manioc that faces Mikea, but Mikea are likely to be very hesitant.

Our analysis suggests a potential problem with the prevalent belief among conservation and development planners that higher-yielding production activities will always be preferred. Decision-makers may prefer lower yielding options if they subjectively discount payoffs because of cost, risk, or delay. Planners in the Mikea Forest region have either assumed that Mikea discount at rates similar to peasants in other parts of the world, or they have not considered time discounting at all. We hope that our analysis demonstrates the potential applicability of experimental economic methods to conservation and development planning. Planners may be able to offer local participants better options if they have a better understand why local people value their current suite of subsistence behaviors in the first place.

Epilogue

Since we conducted this experiment in 2003, manioc cultivation has not filled the economic void left over from the end of slash-and-burn maize. While the savanna village of Vorehe was swelling with forest immigrants in 2003 and the forest camp of Bedo seemed poised to become an agricultural village, we saw very little manioc production in 2004-2006. High temporal discounting rates are probably only part of the problem. There are sociopolitical and agronomic barriers of entry into manioc farming. As forest clearings are improved into intensive farmland, Mikea must protect their land tenure by seeking legal title, a process that is nearly impossible for illiterate people who have never traveled to the city of Toliara where the land office is located. Manioc grown in the sandy soil of the forest tend to be small and bitter compared with manioc grown in the savanna.

References

ALVARD, MICHAEL AND LAWRENCE A. KUZNAR 2001. Deferred harvests: The transition from hunting to animal husbandry. *American Anthropologist* 103:295-311.

BECKER, GARY S., AND CASEY B. MULLIGAN 1997. The endogenous determination of time preference. *The Quarterly Journal of Economics* 112:729-758.

BERNOULLI, D. 1954 (1738). Exposition of a new theory on the measurement of risk. *Econometrica* 22:23-36.

BOOTH, JAMES G., AND PETER HALL 1994. Monte Carlo approximation and the iterated bootstrap. *Biometrika* 81:331-40.

BOYD, ROBERT, AND PETER J. RICHERSON 1985. *Culture and the Evolutionary Process*. Chicago: University of Chicago Press.

CAMERER, COLIN F., AND ROBIN M. HOGARTH 1999. The effects of financial incentives in experiments: A review and capital-labor-production framework. *Journal of Risk and Uncertainty* 19:7-42.

CHAMBERS, ROBERT 1994a. The origins and practice of Participatory Rural Appraisal. *World Development* 22:953-969.

CHAMBERS, ROBERT 1994b. Participatory Rural Appraisal (PRA): Analysis of experience. *World Development* 22:1253-1268.

CHERNICK, MICHAEL R. 1999. *Bootstrap methods: A practitioner's guide*. New York: Wiley.

EFRON, BRADLEY, AND ROBERT TIBSHIRANI 1991. Statistical data analysis and the computer age. *Science* 253:390-5.

ELLIS, FRANK 2000. *Rural Livelihoods and Diversity in Developing Countries*. Oxford: Oxford University Press.

FREDERICK, SHANE, GEORGE LOEWENSTEIN, DANIEL READ, AND ROY F. BUAMEISTER 2003. Time discounting and time preference: A critical review. in *Time and Decision: Economic and Psychological Perspectives on Intertemporal Choice*. Edited by George Loewenstein, Daniel Read, and Roy F. Baumeister, pp. 13-86. New York: Russell Sage Foundation.

FRIEDMAN, MILTON, AND LEONARD J. SAVAGE 1948. The utility analysis of choices involving risk. *Journal of Political Economy* 56:279-304.

GODOY, RICARDO, ELIZABETH BYRON, VICTORIA REYES-GARCÍA, WILLIAM R. LEONARD, KARISHMA PATEL, LILIAN APAZA, EDDY PÉREZ, VINCENT VADEZ, AND DAVID WILKIE 2004. Patience in a foraging-horticultural society: A test of competing hypotheses. *Journal of Anthropological Research* 60:179-202.

GREEN, LEONARD, E. B. FISHER, STEVEN PERLOW, AND LISA SHERMAN 1981. Preference reversal and self-control: Choice as a function of reward amount and delay. *Behaviour Analysis Letters* 1:43-51.

GREEN, LEONARD, NATHANAEL FRISTOE, AND JOEL MYERSON 1994. Temporal discounting and preference reversals in choice between delayed outcomes. *Psychonomic Bulletin and Review* 1:383-9.

GREEN, LEONARD, AND JOEL MYERSON 1996. Exponential versus hyperbolic discounting of delayed outcomes: risk and waiting time. *American Zoologist* 36:496-505.

HENRICH, JOSEPH, AND RICHARD MCELREATH 2002. Are peasants risk-averse decision makers? *Current Anthropology* 43:172-181.

HENRICH, JOSEPH, AND RICHARD MCELREATH 2003. The evolution of cultural evolution. *Evolutionary Anthropology* 12:123-135.

HENRICH, JOSEPH, ROBERT BOYD, SAMUEL BOWLES, COLIN CAMERER, ERNST FEHR, AND HERBERT GINTIS, EDS 2004. *Foundations of Human Sociality: Economic Experiments and Ethnographic Evidence from 15 Small-Scale Societies.* Oxford: Oxford University Press.

HERTWIG, RALPH, AND ANDREAS ORTMANN 2001. Experimental practices in economics: A methodological challenge for psychologists? *Behavioral and Brain Sciences* 24:383-451.

KIRBY, KRIS N., AND NINO N. MARAKOVIC 1996. Delay-discounting probabilistic rewards: Rates decrease as amounts increase. *Psychonomic Bulletin & Review* 3:100-104.

KIRBY, KRIS N., RICARDO GODOY, VICTORIA REYES-GARCÍA, ELIZABETH BYRON, LILIAN APAZA, WILLIAM LEONARD, EDDY PÉREZ, VINCENT VADEZ, AND DAVID WILKIE 2002. Correlates of delay-discount rates: Evidence from Tsimane' Amerindians of the Bolivian rain forest. *Journal of Economic Psychology* 23:291-316.

KIRBY, KRIS N., AND R. J. HERNNSTEIN 1995. Preference reversals due to myopic discounting of delayed reward. *Psychological Science* 6:83-9.

LEE, STEPHEN M. S., AND G. ALASTAIR YOUNG 1999. The effect of Monte Carlo approximation on coverage error of double-bootstrap confidence intervals. *Journal of the Royal Statistical Society, Series B.* 61:353.

MARTIN, MICHAEL A. 1990. On bootstrap iteration for coverage correction in confidence intervals. *Journal of the American Statistical Association* 85:1105-18.

MAZUR, JAMES E. 1987. "An adjusting procedure for studying delayed reinforcement." in *Quantitative Analyses of Behavior: Vol 5: The Effect of Delay and Intervening Events on Reinforcement Value*. Edited by M.L. Commons, J.E. Mazur, J.A. Nevin, and H. Rachlin, pp. 53-73. Hillside, NJ: Erlbaum.

MYERSON, JOEL, AND LEONARD GREEN 1995. Discounting of delayed rewards: Models of individual choice. *Journal of the Experimental Analysis of Behavior* 64:263-76.

NISBETT, RICHARD E., AND TIMOTHY DECAMP WILSON 1977. Telling more than we can know: verbal reports on mental processes. *Psychological Review* 84:231-249.

PENDER, JOHN L. 1996. Discount rates and credit markets: Theory and evidence from rural India. *Journal of Development Economics* 50:257-296.

RACHLIN, HOWARD, ANDRES RAINERI, AND DAVID CROSS 1991. Subjective probability and delay. *Journal of the Experimental Analysis of Behavior* 55:233-44.

TUCKER, BRAM 2003. Mikea origins: Relicts or refugees? *Michigan Discussions in Anthropology.* 14:193-215.

TUCKER, BRAM 2006. A future-discounting explanation for the persistence of a mixed foraging-horticulture strategy among the Mikea of Madagascar. in *Behavioral Ecology and the Transition to Agriculture*. Edited by D. J. Kennett and Bruce Winterhalder. pp. 22-40. Berkeley: University of California Press.

TUCKER, BRAM *in press*. Applying behavioral ecology and experimental economics to conservation and development planning: Example of the Mikea Forest, Madagascar. *Human Nature.*

WOODBURN, JAMES 1980. "Hunters and gatherers today and reconstructions of the past." in *Soviet and Western Anthropology*. Edited by E. Gellner, pp. 95-117. London: Duckworth.

WOODBURN, JAMES 1988. "African hunter-gatherer social organization: Is it best understood as a product of encapsulation?" in *Hunters and Gathererers, Vol 1: History, Evolution, and Social Change*. Edited by T. Ingold, D. Riches, and J. Woodburn, pp. 31-64. Oxford: Berg.

WU LEUNG, WOOT-TSUEN 1968. *Food Composition Table for Use in Africa.* Rome: Food and Agriculture Organization of the United Nations.

YOUNT, JAMES W., TSIAZONERA, AND BRAM TUCKER 2001. Constructing Mikea identity: Past or present links to forest and foraging. *Ethnohistory* 48:257-291.

Captions

Table 1: Narrative responses in time preference choice experiment.

Figure 1: Decision tree illustrating the three questions asked in the first trial. The second and third trials were identical to the first, except the delay in trial two is one month, and the delay in trial three is twelve months.

Figure 2: Comparison of the discounted caloric value of one hectare of maize versus manioc, using discount rates from this study and Pender (1996).

End notes

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[2] The one self-labeled future weaver and vendor of mats chose delayed rewards.

[3] "Social preference" refers to how individuals subjectively tradeoff the value of selfish gains versus the cost of communal retribution (see Henrich et al. 2004).

[4] Pender (1996) conducted 10 different experiments resulting in median k values from 0.26 to 1.19/year. For illustration purposes, our graph considers the midpoint value, 0.72/year (0.06/month, 0.002/day). Pender's analysis uses the exponential discounting model rather than the hyperbolic model. Both models produce similar, increasing functions (Mazur 1987; Myerson and Green 1995). At the scale of our graph, the difference between hyperbolic and exponential curves for these k values does not affect predicted preference.

[5] For simplicity, Figure 2 and our text only considers median k values. The range surrounding the k = 1.4 median (0.4 to 2.5/month) suggests crossovers from 82 to 18 days. The range surround the k = 3.9 median (1.7 to 7.9/month) suggests crossovers from 24 to 10 days.

Figure 1

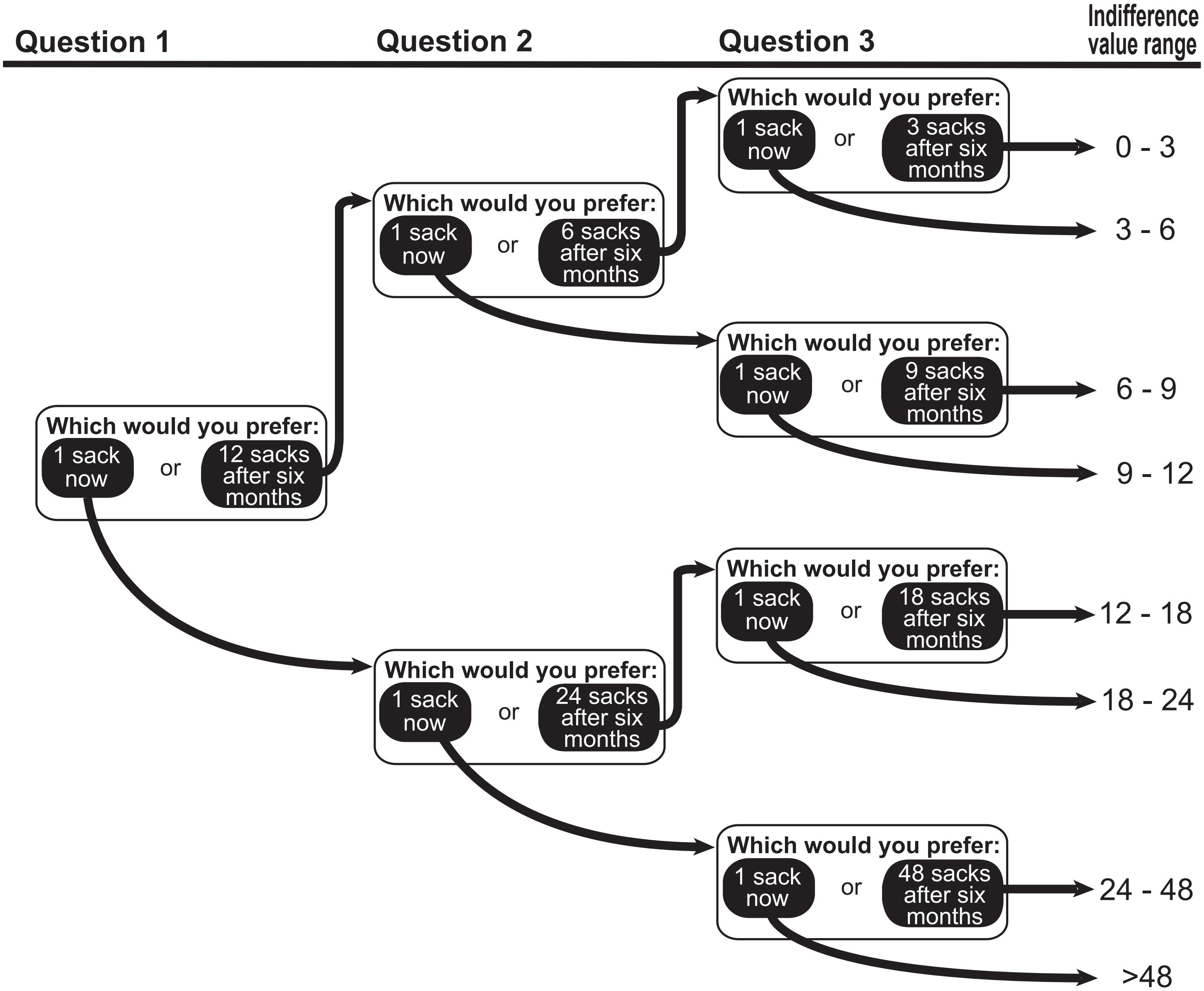
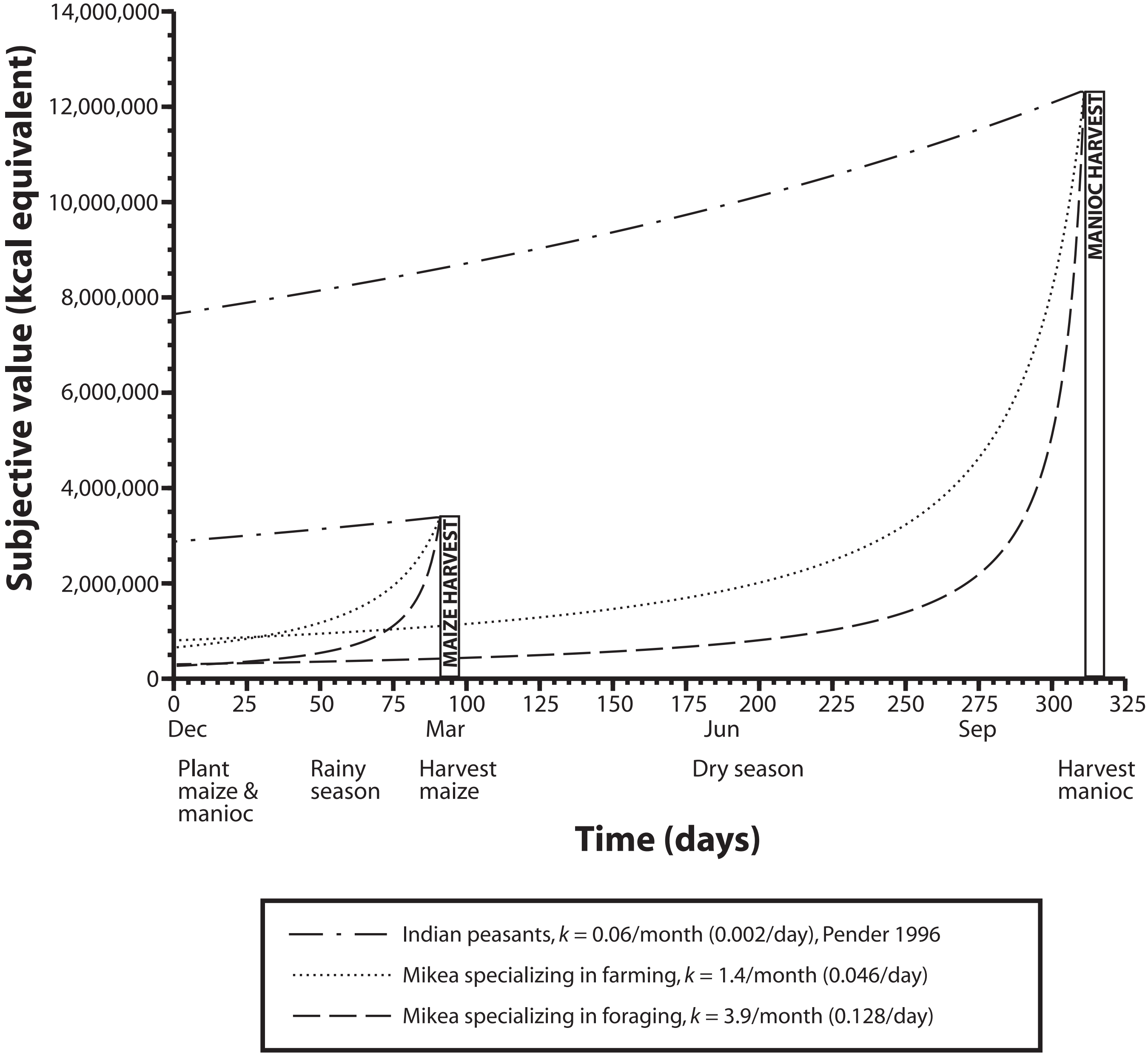

Question 1
Question 2
Question 3
Indifference value range
Which would you prefer:
1 sack now
or
12 sacks after six months
Which would you prefer:
1 sack now
or
6 sacks after six months
Which would you prefer:
1 sack now
or
24 sacks after six months
Which would you prefer:
1 sack now
or
3 sacks after six months
Which would you prefer:
1 sack now
or
9 sacks after six months
Which would you prefer:
1 sack now
or
18 sacks after six months
Which would you prefer:
1 sack now
or
48 sacks after six months
0 - 3
3 - 6
6 - 9
9 - 12
12 - 18
18 - 24
24 - 48
>48

Figure 2


14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
Subjective value (kcal equivalent)
MAIZE HARVEST
MANIOC HARVEST
0
25
50
75
100
125
150
175
200
225
250
275
300
325
Dec
Mar
Jun
Sep
Plant maize & manioc
Rainy season
Harvest maize
Dry season
Harvest manioc
Time (days)
Indian peasants, k = 0.06/month (0.002/day), Pender 1996
Mikea specializing in farming, k = 1.4/month (0.046/day)
Mikea specializing in foraging, k = 3.9/month (0.128/day)