taps

Working Paper Series

Does modernization erode the secular trend of indigenous knowledge?

Ricardo Godoy, Victoria Reyes-García, b, James Broesch, Ian C. Fitzpatrick,
Peter Giovanninni, Maria Ruth Martínez Rodríguez, Naveen Jha, Tomás Huanca,

Tsimane' Amazonian Panel Study Working Paper # 29

Does modernization erode the secular trend of indigenous knowledge?

New evidence from native Amazonians born 1920-1985, Bolivia

Ricardo Godoy[a,*], Victoria Reyes-García[a, b], James Broesch[c], Ian C. Fitzpatrick[d], Peter Giovanninni[e], Maria Ruth Martínez Rodríguez[f], Naveen Jha[a], Tomás Huanca[a], William R. Leonard[g], Susan Tanner[f]

[a,*] Heller School for Social Policy and Management, Brandeis University, Waltham, MA 02454-9110, USA

[b] ICREA and Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, 08193 Bellatera, Barcelona, Spain

[c] Department of Anthropology, Emory University, Atlanta, Georgia 30322, USA

[d] Institute of Social and Cultural Anthropology, University of Oxford, Oxford, OX2 6PE, UK

[e] Center for Pharmacognosy and Phytotherapy, School of Pharmacy, University of London, Department of Pharmacology, University of London, WC1N 1AX, UK

[f] Department of Anthropology, Northwestern University, Evanston, Ill 60208, USA

[g] Department of Anthropology, University of Georgia, Athens, GA 30602, USA

Corresponding author: Ricardo Godoy, Heller School for Social Policy and Management, Brandeis University, Waltham, MA 02454-9110, USA. E-mail: rgodoy@brandeis.edu. Tel. 1-781-736-2784, 2770. Fax. 1-781-736-2774.

Abstract

Researchers using quantitative methods have often found indigenous knowledge wanes as modernization unfolds, but in their estimations they have generally not separated cohort from age effects – the first refers to the effect of the birth period on knowledge and the second refers to the effect of the life cycle on knowledge. Failure to simultaneously take into account both effects can produce the misleading impression that the old know more than the young, and conclude that the difference reflects a secular (long-term) loss of indigenous knowledge. We build on empirical findings from previous researchers and discuss the analytics behind the use of cross-sectional information to estimate the secular change of indigenous knowledge. For the analysis we draw on data from 269 women and 287 men 20+ years of age from a native Amazonian society of foragers-farmers in Bolivia (Tsimane'). We equate indigenous knowledge with theoretical and practical ethnobotanical knowledge. We find weak evidence of a statistically significant secular change in either type of indigenous knowledge. The main finding holds up under many tests of robustness. We discuss the limitations of the study and three explanations for the absence of a secular change in indigenous knowledge.

Keywords: Amazon; Bolivia; ethnobotanical knowledge; ethnobotanical skills; secular trend; Tsimane'

Introduction. Because indigenous knowledge (*sensu* Ohmagari et al (1997))[1] represents a part of humanity's heritage and diversity (Berlin 1992) and because it might enhance many indicators of well-being, researchers have tried to understand why old stocks of indigenous knowledge might vanish so consistently across space and time (Atran et al 2004). We stress *old stocks* to acknowledge that indigenous knowledge changes, and that the loss of indigenous knowledge researchers typically study refers to older, or traditional stocks of knowledge.

Researchers have identified several overlapping reasons for the loss or devolution (Wolff et al 2001) of indigenous knowledge among contemporary populations. Culprits include schooling (Nabhan et al 1993; Boster 1984), occupation (Medin et al 2002; Reyes-García et al. 2006; Godoy et al 1998), market exposure (Brodt 2001), ecological change (Ross 2002), technological transformations (Atran et al. 2004), acculturation (Hill 2004; Benz et al 2000; Zent 2001; Lizarralde 2001), and change in value orientation (Ohmagari and Berkes 1997). The culprits reduce exposure to nature and undermine cultural support for the transmission of indigenous knowledge (Wolff and Medin 2001), thereby abrading its preservation.

To assess the loss of old stocks of indigenous knowledge, researchers have generally compared indicator of indigenous knowledge between the young and the old (e.g., Ohmagari and Berkes 1997) or, less frequently, between people of the same age from samples taken at different times (Zarger et al 2004).

Here we estimate the secular (long-term) trend of indigenous knowledge among adults in one contemporary population of foragers and farmers in the Bolivian Amazon (Tsimane') and do so by separating age effects from cohort effects. Though widely used in disciplines such as economic and labor history, psychology, biological anthropology, and social epidemiology to study the secular trend of outcomes such as physical stature (Henneberg et al 1990; Komlos 1998), earnings of immigrants (Borjas 2004), intelligence (Teasdale et al 2005), and blood pressure (Sjøl et al 1998; Godoy et al 2006a), secular trend analysis, to our knowledge, has never been used to assess changes in indigenous knowledge of contemporary populations.

Background. We reviewed quantitative studies from cultural anthropology, psychology, and conservation biology that measured changes in indigenous knowledge (Atran et al 1999, 2004; Ross 2002; Atran 2001; Zent 2001; Heckler 2002; Case et al 2005; Nabhan and St Antoine 1993; Benz et al. 2000; Ladio et al 2004; Ohmagari and Berkes 1997; Zarger and Stepp 2004). Our work builds on three empirical findings from previous research and provides three methodological improvements.

First, several of these studies (Zarger 2002; Ohmagari and Berkes 1997) and others (Stross 1973; Hunn 2002) suggest that the acquisition of indigenous knowledge might end by the time people reach their late teens, though people may peak in the acquisition of some practical skills (e.g., hunting) later, and indigenous knowledge may erode from lack of use during old age (Reyes-García et al. 2006a). We too assume that indigenous knowledge remains stable after 20 years of age because no new external factor forces change. Second, researchers (Heckler 2002; Zent 2001; Atran et al 1999, 2004; Ross 2002) have shown growing interest in measuring indigenous knowledge through cultural consensus analysis because it might be one of the few culturally-appropriate ways of gauging indigenous knowledge when researchers lack an answer key.

We too use cultural consensus analysis, though later we discuss – and try to overcome – some of its limitations. Third, researchers have shown growing interest in separating theoretical or passive knowledge (e.g., ability to name plants) from active knowledge or practical skills (e.g., ability to use plants)(Atran et al. 2004; Reyes-García et al. 2006). We too measure indigenous knowledge in these two different ways.

We add three methodological improvements. First, we draw on a large sample of observations (n=557). The field-based studies cited in the lead paragraph of this section had a median and mean sample size of 44 and 70 people (minimum=29; maximum=178) so our study represents an improvement in sample size. Second, we estimate the secular trend of indigenous knowledge while controlling for both cohort and age effects. Last, we subject our results to a wide range of tests of robustness.

The estimation strategy. Researchers have taken two approaches to study secular trends (Rodgers 1982; Fienberg et al 1979; Borjas 2005).

The first approach includes two steps: *(a)* following a well-defined age cohort over time to estimate age effects and *(b)* surveying new cohorts of the same age bracket, as in *(a),* in subsequent years to estimate cohort effects. The use of different cohorts and repeated measures of people within a cohort allows one to separate or break the collinearity between cohort and age effects. The approach works best when the outcome changes during adulthood (e.g., blood pressure) (McCarron et al 2001).

In the second approach researchers use only one cross-sectional sample (and no repeated measures of the same subject) to estimate the secular change. To use the second approach the outcome should remain stable during adulthood. Researchers have used the second approach to estimate the secular trend in adult physical stature (Komlos 1998; Pretty et al 1998; Godoy et al 2006) because physical stature remains stable after about 20 years of age (except for slight shrinking linked to aging after ~30 years of age) (van Leer et al 1992; Sorkin et al 1999).

In the second approach, researchers use information on age (combined with year of survey) or birth date to create birth cohorts, defined as a group of people born during the same period (e.g., quinquennium, decade). The two variables – age and birth cohort --- overlap but tell different stories. The age variable picks up the effect of the life-cycle on the outcome whereas the variable for birth cohort picks up the effect of year of birth on the outcome. Failure to simultaneously control for both can produce misleading results.

To illustrate, consider Figure 1a, adapted from (Borjas 2005: 330), with a measure of indigenous knowledge for people over 20 years of age on the y axis and age in years on the x axis. Suppose we had three cohorts of people: one born during the 1920s (old cohort, O), one born during the 1950s (middle-age cohort, M), and one born during the 1980s (young or recent cohort, R). Assume that an additional year of age produced the same marginal increase (β) in indigenous knowledge, and that the same annual increase from aging applied to all three cohorts. Suppose that the oldest cohort started out from a higher initial base of indigenous knowledge because the habitat contained more wildlife and more possibilities of interacting and learning from nature, and because society had in place more cultural support for the transmission of indigenous knowledge. The intercept of the first cohort would be at O. If ecological degradation set in and cultural support for the transmission of knowledge broke down between the birth of the first and the second cohort, then the second cohort would start from a lower base of knowledge. The second cohort would have an intercept at M. If ecological degradation and the breakdown of cultural support continued, the third, youngest, or most recent cohort would start from an even lower base of knowledge than the first two cohorts. The intercept for the most recent cohort would be at R. A cross-sectional analysis of the association between knowledge and age that did not simultaneously take into account age effects and cohort effects would rely only on the right-most points of each cohort (in bold) denoted by O', M', and R', and would produce the misleading parameter estimate of θ for age. The identification strategy would lead one to conclude that age bore a strong positive association with knowledge given by the slope θ when, in fact, it only had a modest association, captured by the slope β.

INSERT FIGURE 1 ABOUT HERE

Figure 1b tells a different story, but again underscores the flawed inferences from insouciance to the simultaneity of age and cohort effects. In Figure 1b we show the accumulation of practical skills starting at, say, 20 years of age between two cohorts. The first cohort starts accumulating practical skills from level O and the second or younger cohort starts accumulating practical skills at a slightly lower level (R). Both cohorts acquire practical skills over their adult life at the rate of β each year. A cross-sectional study that only took into account age and no cohort effects would find that the older cohort averaged K_o of practical skills and that the younger cohort averaged only K_r of practical skills. Such a study would find a large secular loss of skills between the older and younger cohorts given by Δ_{Ko-Kr}. In fact, the secular loss of knowledge between cohorts would amount to only $\Delta_{O'-R'}$.

The story of secular change then is the story of how the outcome (relatively fixed during early adulthood) changes in relation to the birth date of the sample while controlling for age effects. In the study of indigenous knowledge, changes in the intercept might reflect secular changes in variables such as the abundance of wildlife, schooling, cultural support for the transmission of knowledge, occupational opportunities that draw people away or toward nature, and other culprits mentioned in the introduction.

The second approach requires regressing a person's indigenous knowledge as an outcome against age and dummy variables for birth cohorts, and testing whether the coefficients for the dummy variables for birth cohorts, individually or jointly, bear a statistically significant association with indigenous knowledge.

Data and methods. The survey took place during June-September 2005 among *all* households (n=252) in 13 villages straddling the Maniqui river, province of Beni. We stress *all* because the sample did not suffer from an obvious self-selection bias[2]. The survey formed part of a panel study in progress that dates back to 1999 (Godoy et al 2005). We do not use earlier surveys because the 2005 survey had fine-grained questions about indigenous knowledge missing from earlier surveys.

The villages surveyed differed in proximity to the closest market town of San Borja (pop ~ 19,000); mean village-town walking time in hours was 2.58 hours (S.D.=2.74). The 2005 survey was conducted by experienced interviewers and translators who had participated in the panel study since its inception. We collected data on indigenous knowledge among every person over 16 years of age (or younger if they headed a household), but we limit the main analysis to people over 20 years of age to increase the likelihood of excluding people still learning indigenous knowledge. The sample used in the main analysis included 268 adult women and 284 adult men with information on the test of theoretical plant knowledge and 269 adult women and 287 adult men with information on the test of practical plant knowledge.

Outcome variables: Theoretical and practical indigenous knowledge of plants. The main analysis was done using two measures of indigenous knowledge of plants: *(a)* theoretical knowledge (or cultural competence) and *(b)* practical knowledge or skills.

To measure theoretical knowledge we collected similarity judgments across participants using a multiple-choice test of 15 plants selected at random from a list of 92 plants that we developed in an earlier study (Reyes-García 2001). For the tests, participants were asked whether they could use the plants for construction, firewood, food, medicine, or for other ends, and used the most common response as the culturally apt answer. For each plant, participants could choose none, one, or more uses. These responses were analyzed using cultural consensus analysis to calculate individual scores of theoretical ethnobotanical knowledge (Romney et al 1986; Reyes-García et al 2003). So constructed, the measure of theoretical knowledge reflects the most common form of knowledge, which may also be most resistant to change. It is possible that different cohorts might have different competencies. For this reason we later re-do the consensus analysis using answers given by people over 55 years of age as the correct answers.

To measure practical knowledge subjects were asked whether they had ever used 12 plants for a specific purpose (e.g., "Have you ever used coyoj (*zantedeschia sp.*) for medicine?"). None of the question was purposefully false. We summed the number of positive responses to the 12 questions to arrive at a total score of practical knowledge.

The measure of practical knowledge might contain random measurement error since we relied on the self-report of people rather than on objective measures of their skills.

Knowledge scores were transformed using a natural log function. We took the natural logarithm of knowledge scores to make easier the interpretation of results[3]. No subject received a zero in the test of theoretical knowledge so taking logarithms did not reduce the sample size of the variable, but 27 people (women=15, men=12) or 4.86% of the sample had scores of zeros in the test of practical knowledge, so we exclude them from the main analysis[4].

We have no way of telling whether the measures of indigenous knowledge refer to old stocks of knowledge, new stocks of knowledge, or a mix of both. To overcome the limitation, in the sensitivity analysis we use a different measure of indigenous knowledge that refers to skills we know for certain prevailed more widely in the past: knowledge of how to make clay pots, fire, and salt using traditional methods (row 5, Table 3).

<u>Age and birth decade</u>. Participants in the study were asked to estimate their age in years. Because many adults did not know their exact age in years, it is possible that some of the responses were educated guesses, which introduced random measurement error into the variable. (Godoy et al. 2006). We used the year of the survey (2005) and the subject's self-reported age to create seven dummy variables for birth decade: 1920, 1930, 1940, 1950, 1960, 1970, and 1980. Since the survey took place in 2005 and the analysis was limited to people over 20 years of age, the youngest cohort included people born during 1980-1985 (not 1980-1989).

The Tsimane'. Tsimane' number ~8000 people and live in over 100 villages scattered along river banks and logging roads, mostly in the department of Beni. Subsistence centers on hunting, plant collection, fishing, and slash-and-burn farming (Vadez et al 2004). Except for a few Tsimane' who work as school teachers, most Tsimane' make their living from the land.

In recent publications we provide ethnographic and historical background information on the Tsimane' (Godoy et al 2006b, 2006c), including ethnographic descriptions of their ethnobotanical knowledge (Nate et al 2001; Reyes-García et al 2005), so here we discuss processes likely to affect the secular trend in indigenous knowledge.

The first recorded contact of Tsimane' with Westerners goes back to the seventeenth century, but continual exposure to Westerners dates only to the late 1940s and early 1950s. During the first half of the twentieth century, Tsimane' near the town of San Borja worked occasionally as porters for town merchants. They also worked opening cattle trails, constructing the landing strip in San Borja, and helping in small-scale sugar mills. During short spells they hunted for pelts and extracted quinine bark for merchants.

The late 1940s and 1950s saw many socioeconomic changes in the territory of the Tsimane'. The changes included the establishment of permanent Catholic and Protestant missions, the expansion of cattle ranches, and the establishment of the first schools by Protestant missionaries. From the outset schooling took place in Tsimane' with Tsimane' men as teachers (Godoy et al 2006e). Missionaries discouraged the use of myths and shamans, who were mostly men and who have since disappeared. The 1970s saw the building of roads across the territory of the Tsimane' as part of a government policy to reduce the highland population by encouraging migration to the lowlands.

Other important agents of change after the 1950s included traveling traders and various types of encroachers, such as loggers, cattle ranchers, and colonist farmers (Godoy et al 1998). Encroachers hire Tsimane', buy crops and forest goods from Tsimane', and supply Tsimane' with commercial goods and credit but settle permanently and illegally in the land of Tsimane' (Godoy et al 2005).

To earn monetary income, Tsimane' at present work as unskilled laborers in cattle ranches, logging camps, and in the farms of colonist farmers, or else sell forest palms for thatching and farm crops. Sale of goods take place in villages when traveling traders arrive to the village, or in towns when Tsimane' take goods to sell.

Despite many decades of intermittent exposure to the market economy and Westerners, Tsimane' remain highly autarkic. Goods bought in the market accounted for only 2.68% of the total value of household consumption of goods (Godoy et al 2006d). In 2005, 49.70% of adult women, 77.86% of adult men in the bottom income quintile, and 45.30% of adults living far from the market town did not earn any monetary income during the two weeks before the day of the interview. Tsimane' (particularly women) have not become totally acculturated to Bolivian society. For instance, 51.38% of adult women and 7.78% of adult men speak only Tsimane', and 48.03% of adult women and 32.21% of adult men had no formal schooling.

The Tsimane' provide an ideal population to study secular change in indigenous knowledge because continual contact with the outside world started only during the late 1940s and 1950s, so one can compare measures of knowledge between people born before and after those dates. If schooling and modern languages erode indigenous knowledge, as previous evidence suggests (e.g., Hill 2004), then we should see a sharper secular change in indigenous knowledge among men than among women because men have greater fluency in spoken Spanish and more schooling than women. On the other hand, the high level of autarky suggests that we may not find a secular trend in indigenous knowledge.

Results.

Descriptive, visual, and bivariate analysis.

The two forms of knowledge bore a weak correlation with each other. Pair-wise correlation coefficients of theoretical and practical knowledge were only 0.006 (p=0.91) for women and 0.003 (p=0.95) for men[5].

Figure 2 and Table 1 (section I) suggest no visible secular change in theoretical knowledge for Tsimane' born during 1920-1985. On a possible range of scores from 0 to 1, the mean score in theoretical knowledge among women increased by only 0.02 points between women born before 1950 (mean=0.57; S.D.= 0.11) and women born during 1970-1985 (mean=0.59; S.D.= 0.12). Among men, the mean score in theoretical knowledge declined by 0.01 points from 0.56 (S.D.=0.11) among men born before 1950 to 0.55 (S.D.=0.14) among men born in or after 1970. Bivariate regressions (not shown) suggest that among women theoretical knowledge increased by an average of only 0.0002 points/decade (p=0.58) (or 0.03%/decade) and that among men it decreased by an average of only 0.0002 points/decade (p=0.56) (or 0.10%/decade).

INSERT FIGURE 2 AND TABLE 1 ABOUT HERE

Analysis of Figure 2 and Table 1 (section II) suggests a secular decline in practical knowledge. On a possible range of scores from 0 to 12 in the test of practical knowledge, the score among women declined from a mean of 6.61 (S.D.=2.25) among women born before 1950 to 4.01 (S.D.=2.65) among women born in or after 1970. Among men, the mean score in the test of practical knowledge declined from 6.38 (S.D.=2.59) for men born before 1950 to 4.64 (S.D.=2.54) for men born during 1970-1985. Women lost 0.62 points/decade (p=0.001) (or 1.11%/decade) and men lost 0.04 points/decade (p=0.001) (or 0.62%/decade).

In sum, the results of the descriptive, figural, and bivariate analysis suggest no secular change in theoretical knowledge, but they suggest erosion of practical knowledge. The estimates are suggestive but naïve because we did not simultaneously control for age and cohort. We next turn to the results of the multiple regression analysis where we overcome the limitation.

Multiple regression analysis. Table 2 contains the regression results for women (part A) and men (part B). In column [1] we include only dummy variables for birth decades to estimate the association between indigenous knowledge and each birth decade. In column [2] we include only age (and no dummy variables for cohorts) as a covariate to detect possible life-cycle dimensions of indigenous knowledge. In column [3] we include age and dummy variables for birth decades. Column [3] has become the standard way of detecting secular changes in fields such as economic history (Komlos 1998) when the outcome remains largely unchanged during adulthood.

INSERT TABLE 2 ABOUT HERE

<u>*A. Theoretical knowledge (section I, Table 2)*</u>. The analysis of the secular trend of theoretical knowledge (column [1]) with only dummy variables for birth decades as covariates suggests that none of the variables for birth decade bore a statistically significant association with theoretical knowledge among women and that only one of the five birth decades (1940s) bore a statistically significant association with theoretical knowledge among men. An average man born during the 1940s had a 10% higher score in theoretical knowledge than his older peers, but men born during or after 1950 did not differ in significant ways in scores of theoretical knowledge from those born before the 1940s. The results of column [1] mesh with the earlier finding of no visible secular change in theoretical knowledge.

Analysis of column [2], with only age as a covariate, suggests that age bore a negative association with theoretical knowledge among women and a positive association among men, but the magnitude of the association was very small and results were statistically insignificant.

Once we condition for age (column [3]), we see a secular increase in theoretical knowledge among women, but in no case were individual coefficients for birth decade statistically significant at the 95% confidence level. As a group, the variables for birth decade among women bore no statistically significant association with theoretical knowledge ($F=0.93$, $p=0.46$).

Among men, the results of column [3] also suggest no secular change in theoretical knowledge. Two of the coefficients for birth decade (1950 and 1980-1985) bore a negative sign and three of the coefficients for birth decade (1940, 1960, and 1970) bore a positive sign, but in no case where coefficients for birth decade individually or jointly (F=2.05, p=0.07) statistically significant at the 95% confidence level or higher.

In sum, neither women nor men born during 1920-1985 experienced a significant secular change in theoretical knowledge.

B. Practical knowledge (section II, Table 2). Analysis of column [1] confirms the earlier analysis of a secular decline in practical knowledge. All the individual coefficients for birth decade for women and men bore a negative sign, and most coefficients were statistically significant at the 95% confidence level or higher. The results of column [2] suggest that age bore a positive, statistically significant association with practical knowledge; each additional year of age was associated with a 1.15% (p=0.001) and with a 0.66% (p=0.001) improvement in the score of practical knowledge of women and men. Unlike theoretical knowledge, practical knowledge changed after people reach 20 years of age. The results of column [3] suggest that once we condition for age and birth decade, the coefficients for birth decade lose their statistical significance, individually and as a group.

In sum, we find no strong evidence of a secular change in practical knowledge among women or men once we condition for birth decade and age.

Robustness. We did sensitivity analyses to assess how well the main results of column [3] held up (Table 3). The last column and the notes to Table 3 contain a description of the changes made. Most of the results in Table 3 confirm the previous analysis of no statistically significant secular change in indigenous knowledge, with one exception. When we do the analysis of cultural consensus for women using answers provided by people over 55 years of age as correct (section A, row 2) we find a secular increase in theoretical knowledge. For instance, women born during 1960, 1970, and 1980-1985 scored 45-54% higher than women born before 1940 (F=2.35, p=0.04). Perhaps the disappearance of shamans (mostly men) made it necessary for women to acquire knowledge previously held by ritual specialists. Besides the analysis shown in Table 3 we also added interaction terms between age and birth decade and found that none of the interaction terms bore a statistically significant association at the 95% confidence level.

INSERT TABLE 3 ABOUT HERE

Limitations. Limitations of the study include random measurement error in age and in indigenous knowledge – the first would cause a mis-classification of birth cohorts and an attenuation bias and the second would inflate standard errors. Combined, the two types of random measurement error would weaken the statistical results of the analysis.

A second limitation has to do with the small number of observations for older cohorts (e.g., ≤1930). If the sample of older people is a representative random sample of the population of older Tsimane', then the smaller sample size of the older cohorts should not affect the parameter estimates for those birth cohorts, though it will increase the standard error for the cohorts.

A third, related, limitation has to do with attrition biases from possible selective mortality of adults. The bias could work in at least two different ways. *(A)* If Tsimane' experienced a secular decline in indigenous knowledge but older adults with less indigenous knowledge were more likely to die at a given age, then estimates of secular change will produce the incorrect impression of a greater loss. *(B)* If older people with more indigenous knowledge were more likely to die at a given age, then we would be more likely to accept the finding of no secular change. We have no way of separating the two possibilities, but think that the second possibility might carry more weight. As part of the survey, we asked adults whether their parents were alive. We found no difference in the scores of theoretical knowledge between adults whose same-sex parents were alive and adults whose same-sex parent were dead, but we found that adults whose same-sex parent had died scored higher in the test of practical knowledge than adults who had a living parent of the same sex. Results were statistically significant at the 99% confidence level in two-tailed t-test comparing the mean score of practical knowledge between the two groups[6]. If there is a positive association between the indigenous knowledge of an offspring and their same-sex parent, then the secular trend for practical knowledge we estimated might be biased downward. That is, Tsimane' may be experiencing a sharper decline of practical indigenous knowledge than our estimates suggest.

Discussion. We find no significant change in indigenous knowledge. The finding applies to women and men, to theoretical and to practical knowledge, and to several types of ethnobotanical knowledge, such as knowledge of how to use plants for construction, food, and medicines. It also applies to knowledge of how to make fire and ceramic pots, and how to produce salt. We cannot rule out the possibility of a secular decline in other domains of indigenous knowledge that we did not study (e.g., health).

Our finding dovetails with the findings of previous researchers who have found negligible secular change in indigenous knowledge (Case et al. 2005; Ohmagari and Berkes 1997; Zarger and Stepp 2004). Our finding also meshes with a study from historical linguistics by Wolff and Medin (2001). They counted references to trees in the Oxford English Dictionary from 1525 until the twentieth century and found no change in the frequency of words (and presumably local knowledge of trees) from the sixteenth until the eighteenth century. The first quarter of the nineteenth century witnessed a sharp rise in the use of words for trees. References to trees plummeted only with the take off of the Industrial Revolution after the first quarter of the nineteenth century. We return later to the significance of this finding. For now we highlight the stability of botanical knowledge in England during two centuries (1525-1725) that witnessed profound socioeconomic and political changes, such as the enclosure movement, the birth of the British Empire, and the colonization of the New World.

Why might Tsimane' data not show no secular change in indigenous knowledge? We discuss several overlapping explanations beyond the ones having to do with methods discussed earlier.

First, the Tsimane' territory has yet to experience deep political and socioeconomic transformations. Elsewhere we showed the absence of a secular change in standing physical stature among adult Tsimane' born during 1920-1980, and attribute the finding to the protective role and persistence of local forms of social capital, access to natural resources, propinquity to food sources, and to the sporadic and relatively recent history of market exposure (Godoy et al. 2006). If the socioeconomic and natural environment has not yet changed in significant ways, then one would expect people to retain indigenous knowledge since it likely protects outcomes such as health and the management of natural resources. Some of the same reasons that explain the absence of a secular change in adult physical stature might also explain the absence of a secular change in indigenous knowledge. Recall that Wolff and Medin (2001) found that references to trees declined only when England entered the Industrial Revolution. Secular change in indigenous knowledge may track the rate of technological and environmental change in society. The shortcoming of this explanation is that indigenous knowledge does not wane in areas with deep socioeconomic and political transformations, such as England during 1525-1725 or the highlands of Chiapas during the second half of the twentieth century (Zarger and Stepp 2004).

A second explanation has to do with the absence of secular change in childhood experiences. Studies cited earlier suggest that the acquisition of indigenous knowledge, much like the acquisition of language, takes place early in life and that it may end by the late teens. It is an open question whether learning takes place mainly from elders or from peers, including siblings, but the evidence reviewed by Zarger (2002) suggests that children learn indigenous knowledge through hands-on experience, play, and direct observations. If so, then one would have to ask whether Tsimane' childhood has undergone significant secular change, and our impression is that it may have not. In theory, schooling among the Tsimane' is compulsory. In practice, teachers and students routinely skip school when household chores pull them away from school. The school day ends at noon, so children have afternoons, evenings, and weekends to interact with nature and play with each other in their villages, and, in so doing, acquire indigenous knowledge. Permanent out-migration is rare, even to the town of San Borja. Schooling among the Tsimane' has not eroded social capital (Godoy et al. 2006e) because instruction has always been in Tsimane', with Tsimane' teachers, using textbooks written in Tsimane'. Demand for schooling has been weak because of the absence of employment opportunities or technological innovations that require schooling or academic skills. A shortcoming of the second explanation is that several studies cited in the introduction suggest that even small amounts of schooling abrade indigenous knowledge.

A third explanation has to do with the possible positive role of modernization in the persistence of some aspects of indigenous knowledge. Improvements in transport physical infrastructure and in modes of transportation have lowered travel costs in the area. Lower transport costs make it easier for Tsimane' to move over a wider area to visit and to work and, in so doing, transmit and learn indigenous knowledge that may not have been as readily available to them before. In a study done in 2000 in 58 villages we found that Tsimane' shared plant knowledge widely (Reyes-García et al 2003), in part perhaps from the great amount of travel between villages (Ellis 1996). The problem with this explanation is that many studies cited earlier suggest that modernization erodes indigenous knowledge. It is possible that modernization simultaneously weakens and strengthen indigenous knowledge, and that among the Tsimane' the positive effects so far have outweighed the corrosive effects.

Conclusion. A convincing identification strategy to estimate the secular change of adult indigenous knowledge among contemporary populations requires *(a)* taking repeated measures from people of the same age bracket at regular intervals to assess the effects of age on indigenous knowledge and *(b)* using several surveys to identify different cohorts. In this way, one could assess secular changes between people of the same age but born during different years. With such data one could separate age from cohort effects

(Fienberg and Mason 1979). No data in cultural anthropology known to us meets these criteria. Long-term quantitative panel studies in anthropology are rare, and so are longitudinal studies of how people acquire indigenous knowledge.

Without the ideal data set, one is left with only single cross-sectional information to infer the secular change in indigenous knowledge. When using the second-best approach one needs to distinguish between age and cohort effects. Researchers have often treated age and cohort effects in a cavalier fashion. They have confused older people knowing more – because they are old – with cohorts exhibiting different attributes because they were exposed - as a cohort - to influences that left an indelible imprint on the way the cohort experiences the world *sensu* Atran et al. (2004).

Table 1

Comparison of indigenous knowledge among Tsimane' women and men by birth decade, 1920-1985

Birth decade:	***A. Women***			***B. Men***			***C. Difference: Women-men***	
	N	***Mean***	***S.D.***	***N***	***Mean***	***S.D.***	***Mean***	***S.E.***
I. Theoretical knowledge								
1920	12	0.58	0.12	9	0.56	0.09	0.01	0.05
1930	23	0.59	0.09	31	0.54	0.11	0.05	0.02
1940	19	0.55	0.11	23	0.60	0.10	-0.04	0.03
1950	25	0.58	0.13	24	0.52	0.14	0.06	0.04
1960	48	0.60	0.14	52	0.57	0.13	0.03	0.02
1970	68	0.60	0.12	65	0.58	0.15	0.02	0.02
1980-1985	73	0.58	0.12	80	0.53	0.14	0.05**	0.02
Total	268	0.59	0.12	284	0.55	0.13	0.03***	0.01
II. Practical knowledge								
1920	12	7.25	2.37	9	7.11	2.08	0.13	0.99
1930	23	6.65	1.87	31	6.58	2.64	0.07	0.64
1940	20	6.20	2.58	23	5.82	2.70	0.37	0.81
1950	25	5.56	3.08	24	5.45	1.99	0.10	0.74
1960	48	5.04	2.38	52	5.34	2.66	-0.30	0.50
1970	68	4.64	2.55	67	4.95	2.48	-0.30	0.43
1980-1985	73	3.42	2.63	81	4.39	2.59	-0.97 **	0.42
Total	269	4.87	2.76	287	5.22	2.62	-0.34	0.22

S.E.=standard error. *** and ** significant at ≤1% and ≤5% in two-tailed t-test comparing difference in mean values between women and men.

Table 2

Regression results: Secular trend of indigenous knowledge, Tsimane' adults born 1920-1985

I. Dependent variable = Theoretical knowledge (in logarithms)						
Explanatory variables:	**A. Women**			**B. Men**		
	[1]	**[2]**	**[3]**	**[1]**	**[2]**	**[3]**
Birth decade (reference: <1940)						
1940	-0.06	^	0.04	0.10**	^	0.11
1950	-0.02	^	0.17	-0.08	^	-0.06
1960	0.006	^	0.29	0.03	^	0.06
1970	0.02	^	0.38	0.04	^	0.08
1980-1985	-0.01	^	0.42	-0.05	^	-0.006
Age (years)	^	-.00005	0.008	^	0.0009	0.001
Constant	-0.54***	-0.54***	-1.16***	-0.62***	-0.66***	-0.69
R2	0.007	0.0001	0.01	0.03	0.002	0.03
Observations	268			284		
Joint: birth decade	NA	NA	0.93 (0.46)	NA	NA	2.05(0.07)
II. Dependent variable = Practical knowledge (in logarithms)						
1940	-0.14	^	0.07	-0.19	^	-0.04
1950	-0.39**	^	-0.0008	-0.21	^	0.07
1960	-0.40***	^	0.16	-0.23**	^	0.17
1970	-0.41***	^	0.31	-0.32***	^	0.22
1980-1985	-0.65***	^	0.21	-0.35***	^	0.28
Age (years)	^	0.01***	0.01	^	0.006***	0.012
Constant	1.87***	1.01***	0.63	1.82***	1.31***	0.90
R2	0.11	0.11	0.12	0.05	0.05	0.05
Observations	254			275		
Joint: birth decade	NA	NA	0.65 (0.65)	NA	NA	0.27 (0.92)

*** and ** significant at ≤1% and ≤5%. Regressions are ordinary-least squares. Robust standard errors used when probability of exceeding χ^2 value in Breusch-Pagan test <5%. ^=variable intentionally left out. 'Joint'=tests of joint statistical significance for all dummy variables for birth decade and, in parenthesis, p>F. NA = not applicable.

Table 3

Sensitivity analysis

#	Coefficients of birth decade: 1940	1950	1960	1970	1980-1985	Joint: F & p>F	Description of changes to column [3], Table 2:
A. Women							
1a	.04	.17	.29	.38	.42	.93(.46)	Baseline: Theoretical, column [3], IA, Table 2
1b	.07	-.0008	.16	.31	.21	.65(.65)	Baseline: Practical, column [3], IIA, Table 2
2	.09**	.20	.45**	.50**	.54**	2.35(.04)	Cultural consensus using answers from people 55+ as correct
3	.08	.26	.58**	.66**	.72	1.79(.11)	Cultural competence using matching method
4	.05	.11	.32**	.35	.36	2.26(.04)	Total number of plants known in multiple-choice test
5	.24	.28	.33	1.51	1.22	1.23(.29)	Traditional skills to make fire, clay pots and salt; tobit
6	.18	.07	-.23	-.38	-.68	.53(.75)	Applied skills only of medicinal plants; tobit
7	-.01	.04	.10	.15	.15	.35(.87)	Like 1a but limited to household heads
8	.05	-.09	.07	.21	.09	.62(.68)	Like 1b but limited to household heads
9	-.008	-.03	-.005	-.02	NA	.18(.94)	Cultural consensus, 2000 survey, n=219
10	-.05	-.0004	.04	.07	.009	1.11(.35)	Like 1a but includes household heads<20 years of age
11	-.006	-.13	-.02	.08	-.08	.78(.56)	Like 1b but includes household heads<20 years of age
12	.05	.10	.33	.38	.39	1.54(.17)	Like 2 only of medicinal plants
13	.08	.23	.43**	.47**	.48	2.31(.04)	Like 2 only of plants for construction
14	.06	.12	.36**	.41	.41	1.84(.10)	Like 2 only of plants for food
15	.25	.37	.61	.87	.28	.55(.73)	Raw values of skills (i.e., no logarithms taken)
B. Men							
1a	.11	-.06	.06	.08	-.006	2.05(.07)	Baseline: Theoretical, column [3], IB, Table 2
1b	-.04	.07	.17	.22	.28	0.27(.92)	Baseline: Practical, column [3], IIB, Table 2
2	.09	.16	.33	.41	.41	1.49(.19)	Cultural consensus using answers from people 55+ as correct
3	.21	.13	.57**	.72	.76	1.15(.33)	Cultural competence using matching method
4	.08	.15	.31**	.38	.39	1.46(.20)	Total number of plants known in multiple-choice test
5	-.38	-.20	-.32	-.07	-.56	1.01(.41)	Traditional skills to make fire, clay pots, salt; tobit
6	.83	1.02	2.0**	2.16	2.41	1.41(.22)	Applied skills only of medicinal plants; tobit
7	.08	-.11	.01	.03	-.02	1.31(.25)	Like 1a but limited to household heads
8	-.02	.20	.28	.35	.37	.42(.83)	Like 1b but limited to household heads
9	-.06	.005	.06	.03	NA	1.68(.15)	Cultural consensus, 2000 survey, n=262
10	.12	-.06	.07	.09	-.01	2.39(.03)	Like 1a but includes household heads<20 years of age
11	.02	.21	.37	.48	.53	.57(.72)	Like 1b but includes household heads<20 years of age
12	.06	.09	.25	.30	.31	.90(.48)	Like 2 only of medicinal plants
13	.11	.13	.26	.34	.29	1.83(.10)	Like 2 only of plants for construction
14	.12	.24	.40**	.47	.47	1.74(.12)	Like 2 only of plants for food
15	.02	.45	1.07	1.45	1.46	.27(.92)	Raw values of skills (i.e., no logarithms taken)

Same notes as Table 2. NA=not applicable. Tobit in rows 5-6 refers to Tobit regressions.

Explanations below match row numbers:

[3] The matching method is sensitive to response bias when measuring similarity among respondents. The covariance method is insensitive to response bias, but is sensitive to the share of 1s and 0s (Batchelder et al 1988;Weller et al 1997). Bias can inflate the knowledge scores using either method.

Table 3 - continued

[5] We explore knowledge of how to make salt, fire, and ceramics because ethnographic evidence suggests that they might be dying arts. The simulation allows us be more confident that our measure of knowledge reflect old knowledge. All three dimensions of skills in row 5 have been replaced by the purchase of industrial substitutes, including matches, cigarette lighters, metal pots, and iodized salt. Answers to these questions are not part of Table 2.

[9] Refers to an earlier study (2000) of ethnobotanical knowledge. We used cultural competence with 511 households in 58 villages (Reyes-García et al. 2003).

Figure 1. Indigenous knowledge in relation to age and birth cohort

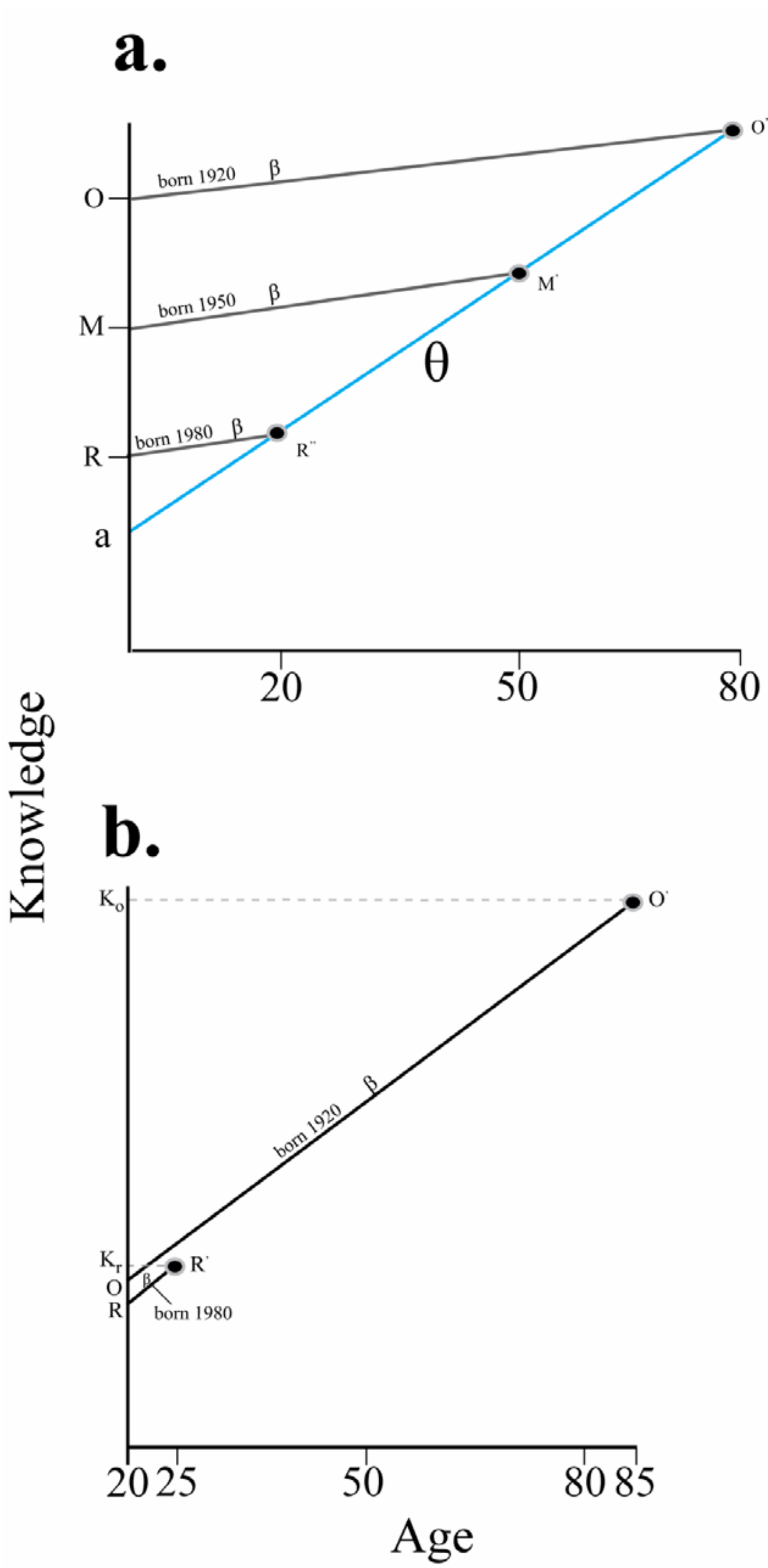
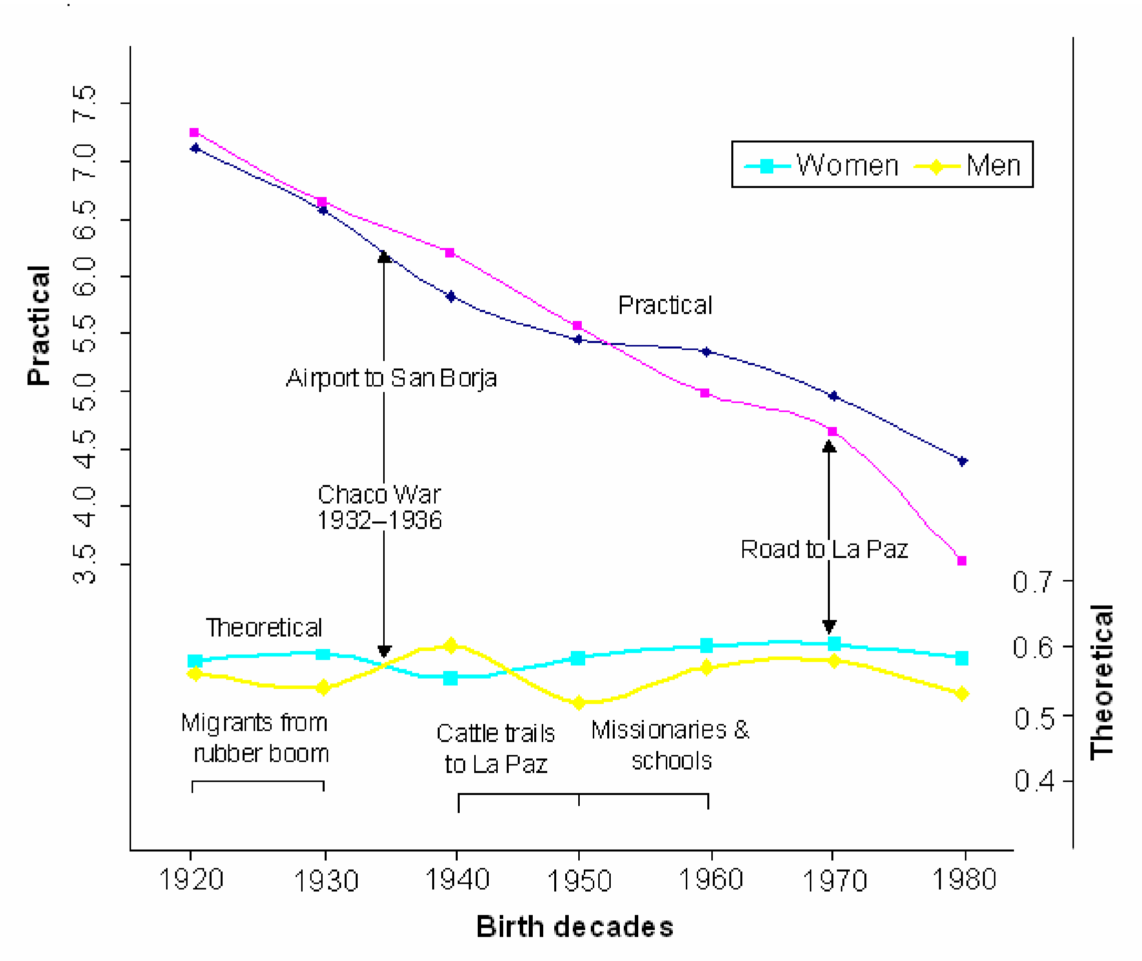


Figure 2. Theoretical and practical indigenous knowledge, by birth decade and sex



Acknowledgements

Research was funded by grants from the programs of Biological and Cultural Anthropology of the National Science Foundation (0134225, 0200767, and 0322380). Thanks go to J. Cari, S. Cari, E. Conde, V. Cuata, B. Nate, D. Pache, J. Pache, P. Pache, M. Roca, and E. Tayo for help collecting data and logistical support. Thanks also go to the Gran Consejo Tsimane' for their continuous support throughout this research project, and to Rick Stepp for commenting on an earlier version of the paper.

References

Atran S. 2001. The vanishing landscape of the Petén Maya lowlands. In: Maffi L, editor. On Biocultural Diversity. Linking Language, Knowledge, and the Environment. Washington, D.C.: Smithsonian Institution Press; p 157-174.

Atran S, Medin D, Ross N. 1999. Folk ecology and commons management in the Maya lowland. Proceeding of the National Academy of Sciences 96:7598-603.

Atran S, Medin D, Ross N. 2004. Evolution and devolution of knowledge: A tale of two biologies. Journal of the Royal Anthropological Institute 10:395-420.

Batchelder W, Romney AK. 1988. Test theory without an answer key. Psychometrika 53:71-92.

Benz BF, Cevallos J, Santana F, Rosales J, Graf S. 2000. Losing knowledge about plant use in the sierra de Manantlán Biosphere Reserve, Mexico. Economic Botany 54(2):183-91.

Berlin B. 1992. Ethnobotanical classification: Principles of categorization of plants and animals in traditional societies. Princeton, New Jersey: Princeton University Press.

Borjas GJ. 2004. Assimilation, changes in cohort quality, and the earnings of immigrants. Journal of Labor Economics 3(4):463-89.

Borjas GJ. 2005. Labor Economics. 3rd ed. New York: McGraw-Hill.

Boster JS. 1984. Classification, cultivation, and selection of Aguaruna cultivars of Manihot esculenta (Euphorbiaceae). Adv Econ Bot 1:34-47.

Brodt S. 2001. A systems perspective on the conservation and erosion of indigenous agricultural knowledge in Central India. Hum Ecol 29(1):99-120.

Case RJ, Pauli GF, Soejarto DD. 2005. Factors in maintaining indigenous knowledge among ethnic communities of Manus Island. Economic Botany 59(4):356-65.

Ellen, R. and H. Harris. 2000. Introduction. In Indigenous Environmental Knowledge and its Transformations, edited by R. Ellen, P. Parkes, and A. Bicker. Amsterdam: Hardwood Academic Publishers.

Ellis R. 1996. A taste for movement: An exploration of the social ethics of the Tsimanes of lowland Bolivia [Ph.D. dissertation]. St. Andrews University, Scotland.

Fienberg SE, Mason WM. 1979. Identification and estimation of age-period-cohort models in the analysis of discrete archival data. Sociological Methodology 10:1-67.

Godoy RA, Brokaw N, Wilkie DS, Colón D, Palermo A, Lye S, Wei S. 1998. Of trade and cognition: markets and the loss of folk knowledge among the Tawahka Indians of the Honduran rain forest. J Anthr Res 54:219-33.

Godoy R, Leonard WR, Reyes-García V, Goodman E, McDade TW, Huanca T, Tanner S, Vadez V. 2006. Physical stature of adult Tsimane' Amerindians, Bolivian Amazon in the 20th century. Economics and Human Biology 4:184-205.

Godoy RA, Goodman E, Gravlee CC, Levins R, Seyfried C, Caram M. 2006. A comparison of blood pressure and hypertension between men born 1886-1930 in Puerto Rico and the USA mainland. Economics and Human Biology. In press.

Godoy RA, Jacobson M, De Castro J, Aliaga V, Romero J, Davis A. 1998. The role of tenure security and private time preference in neotropical deforestation. Land Economics 74(2):162-70.

Godoy RA, Reyes-García V, Byron E, Leonard WR, Vadez V. 2005. The effect of market economies on the well-being of indigenous people and on their use of renewable natural resources. Ann Rev Anthro 34:122-38.

Godoy RA, Reyes-García V, Huanca T, Leonard WR, McDade TW, Tanner S, Vadez V, Seyfried C. 2006. Signaling by consumption in a native Amazonian society. Evolution and Human Behavior In press.

Godoy RA, Reyes-García V, Huanca T, Leonard WR, Vadez V, Valdés-Galicia C, Zhao D. 2005. Why do subsistence-level people join the market economy? Testing hypotheses of push and pull determinants in Bolivian Amazonia. J Anthr Res 61(2):157-78.

Godoy RA, Reyes-García V, Leonard WR, Huanca T, McDade TW, Vadez V, Tanner S, Patel A. 2006. Spousal empowerment and nutritional status in a native Amazonian society. Social Science & Medicine 63:1517-1530.

Godoy RA, Reyes-García V, Vadez V, Leonard WR, Byron E. 2006. How well do foragers protect food consumption? Panel evidence from a native Amazonian society in Bolivia. Hum Ecol In press.

Godoy RA, Seyfried C, Reyes-García V, Huanca T, Leonard WR, McDade TW, Tanner S, Vadez V. 2006. Schooling's contribution to social capital: A study from a native Amazonian society in Bolivia. Comparative Education In press.

Heckler S. 2002. Traditional ethnobotanical knowledge loss and gender among the Piaroa. In: Stepp JR, Wyndham FS, Zarger RK, editors. Ethnobiology and Biocultural Diversity. Proceedings of the Seventh International Congress of Ethnobiology. Athens, Georgia: University of Georgia Press; p 532-548.

Henneberg M, van den Berg ER. 1990. Test of socioeconomic causation of secular trend: Stature changes among favored and oppressed South Africans are parallel. Am J Phys Anthro 83:459-65.

Hill JH. 2004. What is lost when names are forgotten? In: Sanga G, Ortallis G, editors. Nature Knowledge, Ethnoscience, Cognition, and Utility. New York: Berhahm Books; p 161-184.

Hunn ES. 2002. Evidence for the precocious acquisition of plant knowledge by Zapotec children. In: Stepp JR, Wyndham FS, Zarger RK, editors. Ethnobiology and Biocultural Diversity. Athens, Georgia: International Society of Ethnobiology; p 604-613.

Komlos J. 1998. Shrinking in a growing economy? The mystery of physical stature during the Industrial Revolution. The Journal of Economic History 58(3):779-802.

Ladio AH, Lozada M. 2004. Patterns of use and knowledge of wild edible plants in distinct ecological environments: A case study of a Mapuche community from northwestern Patagonia. Biodiversity Conservation 13:1153-73.

Lizarralde M. 2001. Biodiversity and loss of indigenous languages and knowledge in South America. In: Maffi L, editor. Biocultural diversity. Linking Language, Knowledge, and the Environment. Washington, D.C.: Smithsonian Institution Press; p 265-280.

McCarron P, Okasha M, McEwen J, Davey Smith G. 2001. Changes in blood pressure among students attending Glasgow University between 1948 and 1968: Analyses of cross sectional surveys. British Medical Journal 322:885-9.

Medin D, Ross N, Atran S, Burnett R, Blok S. 2002. Categorization and reasoning in relation to culture and expertise. In: Ross B, editor. Psychology of Learning and Motivation. New York: Academic Press; p 1-41.

Nabhan GP, St Antoine S. 1993. The loss of floral and faunal story: The extinction of experience. In: Kellert SR, Wilson EO, editors. The Biophilia Hypothesis. Washington, D.C.: Island Press; p 229-250.

Nate A, Ista D, Reyes-García V. 2001. Plantas Útiles y su Aprovechamiento en la Comunidad Tsimane' de Yaranda. Santa Cruz, Bolivia: CIDOB-DFIB.

Ohmagari K, Berkes F. 1997. Transmission of indigenous knowledge and bush skills among the Western James Bay Cree women of sub artic Canada. Hum Ecol 25(2):197-221.

Pretty GL, Henneberg M, Lambert KM. 1998. Trends in stature in the South Australian Aboriginal Murraylands. Am J Phys Anthro 106:505-14.

Reyes-García V. 2001. Indigenous people, ethnobotanical knowledge, and market economy: A case study of the Tsimane' Amerindians in lowland Bolivia [Ph.D. dissertation]. University of Florida, Gainesville.

Reyes-García V, Byron E, Godoy RA, Vadez V, Perez E, Leonard WR, Wilkie D. 2003. Measuring culture as shared knowledge: Do data collection formats matter? Data from Tsimane' Amerindians, Bolivia. Field Methods 15(2):1-22.

Reyes-García V, Godoy RA, Vadez V, Apaza L, Byron E, Huanca T, Leonard W, Pérez E. 2003a. Indigenous people share botanical knowledge. Estimates from an Amerindian society in Bolivia. Science 299:1707.

Reyes-García V, Vadez V, Byron E, Apaza L, Leonard WR, Pérez E, Wilkie D. 2005. Market economy and the loss of folk knowledge of plant uses: Estimates from the Tsimane' of the Bolivian Amazon. Curr Anthro 46(4):651-6.

Reyes-García V, Vadez V, Huanca T., Leonard WR, McDade T. 2006. Economic development and local ecological knowledge: A deadlock? Data from a native Amazonian society. Human Ecology. In press.

Reyes-García, V., R. Godoy, T. Huanca, W.R. Leonard, T. McDade, S. Tanner, V. Vadez. 2006[a]. The origins of monetary inequality: The role of patience, human capital, and the division of labor. Evolution and Human Behavior. In Press.

Rodgers WL. 1982. Estimable functions of age, period, and cohort effects. American Sociological Review 47(6):774-87.

Romney AK, Weller S, Batchelder W. 1986. Culture as consensus: A theory of culture and informant accuracy. Amer Anthro 88:313-38.

Ross N. 2002a. Cognitive aspects of intergenerational change: Mental models, cultural change, and environmental behavior among the Lacandón Maya of southern Mexico. Hum Org 61(2):125-38.

Ross N. 2002b. Lacandón Maya intergenerational change and the erosion of folk biological knowledge. In: Stepp JR, Wyndham FS, Zarger RK, editors. Ethnobiology and Biocultural Diversity. Proceedings of the Seventh International Congress of Ethnobiology. Athens, Georgia: University of Georgia Press; p 585-592.

Sjøl A, Korsgård K, Schroll M. 1998. Secular trends in blood pressure levels in Denmark 1964-1991. International Journal of Epidemiology 27:614-22.

Sorkin JD, Muller DC, Andres R. 1999. Longitudinal change in height of men and women: Implications for interpretation of the body mass index. American Journal of Epidemiology 150(9):969-77.

Stross B. 1973. Acquisition of botanical terminology by Tzeltal children. In: Edmonson MS, editor. Meaning in Mayan Languages. The Hague: Mouton; p 107-141.

Teasdale TW, Owen DR. 2005. A long-term rise and recent decline in intelligence test performance: The Flynn effects in reverse. Personality and Individual Differences 39:837-43.

Vadez V, Reyes-García V, Godoy RA, Apaza L, Byron E, Huanca T, Leonard WR, Wilkie D, Pérez E. 2004. Does integration to the market threaten agricultural diversity? Panel and cross-sectional evidence from a horticultural-foraging society in the Bolivian Amazon. Hum Ecol 32(5):635-46.

van Leer EM, van Noord PAH, Seidell JC. 1992. Components of adult height and height loss. Secular trend and effects of aging in women in the DOM project. Annals of Epidemiology 2(5):611-5.

Weller S, Mann NC. Assessing rater performance without a "gold standard" using consensus theory. Medical Decision Making 17, 71-79. 1997.

Wolff P, Medin DL. 2001. Measuring the evolution and devolution of folk-biological knowledge. In: Maffi L, editor. On biocultural diversity. Linking language, knowledge, and the environment. Washington, D.C.: Smithsonian Institution Press; p 213-227.

Zarger RK. 2002. Acquisition and transmission of subsistence knowledge by Q'eqchi' Maya in Belize. In: Stepp JR, Wyndham FS, Zarger RK, editors. Ethnobiology and Biocultural Diversity. Proceedings of the Seventh International Congress of Ethnobiology. Athens, Georgia: University of Georgia Press; p 593-603.

Zarger RK, Stepp JR. 2004. Persistence of botanical knowledge among Tzeltal Maya children. Curr Anthro 45(3):413-8.

Zent S. 2001. Acculturation and ethnobotanical knowledge loss among the Piaroa of Venezuela: Demonstration of a quantitative method for the empirical study of traditional ecological knowledge change. In: Maffi L, editor. On Biocultural Diversity: Linking

Language, Knowledge, and the Environment. Washington, D.C.: Smithsonian Institution Press; p 190-211.

End notes

[1] They define indigenous knowledge as "local knowledge held by indigenous peoples, or local knowledge unique to a given culture or society" and add that their definition covers "not only ecological knowledge but other knowledge and skills related to making a livelihood" (p. 199). See also Ellen and Harris (2000).

[2] We could have a self-selected sample if people with either more or with less indigenous knowledge had left the villages before we started the panel study. We have no way of assessing the possibility.

[3] When the outcome variable is in logarithms, one can read the coefficient of the explanatory variable in a regression as a percentage change from a marginal change in the explanatory variable.

[4] We re-did the analysis of practical skills using the raw, un-transformed scores, and also found no significant secular trend (row 15, Table 3).

[5] We have no convincing explanation for the finding beyond the obvious point that the two dimensions of knowledge pick up different types of experiences.

[6] We can only speculate about the results. Perhaps an offspring whose same-sex parent had died might have had to learn more indigenous knowledge than offspring whose same-sex parent was alive. Perhaps the latter could rely on their parents whereas the former had to fend on their own. The explanation is not entirely convincing since we have shown that Tsimane' share knowledge widely (Reyes-García et al. 2003a). It is also possible that a boy (or girl) whose father (or mother) was much older (and therefore more likely to be dead at the time of the interview) would have had a same-sex parent with more practical knowledge because the parent was much older. An offspring whose

---

livelihood depends on the environment and who had a much older same-sex parent may face stronger incentives to learn practical skills from the parent.