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Cultural change and traditional ecological knowledge. An empirical analysis from the Tsimane' in the Bolivian Amazon

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Abstract

Among the different factors associated to change in traditional ecological knowledge, the study of the relations between cultural change and traditional ecological knowledge has received scan and inadequate scholarly attention. Using data from indigenous peoples of an Amazonian society facing increasing exposure to the mainstream Bolivian society, we analyzed the relation between traditional ecological knowledge, proxied with individual plant use knowledge (n=484), and cultural change, proxied with individual- and village-level (n=47) measures of attachment to traditional beliefs and values. We found that both the individual level of detachment to traditional values and the village level of agreement in detachment to traditional values were associated with individual levels of plant use knowledge, irrespective of other proxy measures for cultural change. Because both the individual- and the village-level variables bear statistically significant associations with plant use knowledge, our results suggest that both the individual- and the supra-individual level processes of cultural change are related to the erosion of plant use knowledge. Results from our work highlight the importance of analyzing processes that happen at intermediary social units -the village in our case study- to explain changes in traditional ecological knowledge.

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Keywords

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1 Introduction

As indigenous peoples around the world are increasingly exposed to Western cultural and economic norms and patterns, interest has grown on the consequences of globalization for the wellbeing of such indigenous societies, their world views, and their traditional ecological knowledge (Godoy, et al. 2005a; Lu 2007; Maffi 2002). Traditional ecological knowledge has been defined as "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relation of living beings (including humans) with one another and with their environment" (Berkes, et al. 2000):1252). Current research widely acknowledges that traditional ecological knowledge is dynamic and constantly changing (Berkes, et al. 2000; Gómez-Baggethun and Reyes-García 2013) and recognizes that the speed and intensity of change in traditional knowledge systems varies across societies (Gomez-Baggethun, et al. 2010; Reyes-García, et al. 2013a) and knowledge domains (Reyes-García, et al. 2013b). However, there is also agreement that, over all, bodies of traditional ecological knowledge are decreasing (Reyes-García, et al. in press; Zent and Maffi 2010). Given that traditional ecological knowledge holds the potential to contribute to development and biodiversity conservation (Berkes and Davidson-Hunt 2006; Toledo 2002), the finding of decreasing trends calls for research on the drivers of such a change.

From previous research, we know that the drivers of traditional ecological knowledge change are complex, multifaceted, and partially contextual. Some of the studied drivers of change for traditional ecological knowledge include a) the influences of schooling, loss of local languages (Maffi 2005; McCarter and Gavin 2011; Reyes-García 2013) and religious conversion (Cook and Offit 2008; Tang and Tang 2010); b) changes in land use (Gray, et al. 2008; Paneque-Gálvez, et al. 2013; Pérez-Llorente, et al. 2013); c) integration of local communities into market economies (Godoy, et al. 2005a; Reyes-Garcia, et al. 2005); d) loss of access to resources through conservation programs and other management regulations (Gomez-Baggethun, et al. 2010; Ruiz-Mallén and Corbera 2013); e) development aid work and mechanization (Stone 2007); and f) climate change (Eakin 2000; Morton 2007). While those factors are often intermingled, it is important to try to disentangle the pathways through which they influence traditional knowledge systems.

In this article we contribute to this body of research by analyzing the association between traditional ecological knowledge (proxied by plant use knowledge) and cultural change (proxied by individual- and village-level indicators of changes regarding traditional beliefs and values). Cultural change refers to the individual and supra-individual processes that take place when individuals from different cultures interact and to the subsequent changes in their world views and/or in the original cultural patterns of either or both groups (Berry 2008; Redfield, et al. 1936; Rudmin 2009). Psychologists and sociologists have studied the process of cultural change among immigrant people (Berry 2008; Berry 1980; Rudmin 2009) and

anthropologists among indigenous peoples, who face different challenges than immigrant populations as they have often been involuntarily driven to cultural contact on their own land. Initial studies of cultural change among indigenous peoples mostly referred to this process as 'acculturation', and conceptualized it as lineal and unidirectional (see for example (Herskovits 1958; Linton 1940). Furthermore, the assumption was that the process would lead to the 'modernization' and 'development' of indigenous peoples, with the subsequent disappearance of the indigenous groups as distinctive social entities with rich cultural traditions and heritage (see (de la Pena 2005)). Most scholars now depart from this view, moving to more complex theoretical models of cultural change that emphasize hybridization and orthogonal cultural identification, (i.e., the fact that someone fell identified with both ends) (Rudmin 2009) and acknowledge individual agency in the process of change (Santos-Guerrero 2009).

Cultural change refers both to individual and supra-individual processes (Berry 2008; Berry, et al. 1986). People can experience an individual process that leads to change in their traditional beliefs, values, and behaviors in which they were enculturated without this process necessarily affecting their original culture (as in the case of an indigenous person who migrates to a town). But cultures can also be the subject of change when there is a shared agreement in the modification or adoption of the dominant social paradigm, which then become part of the new social and cultural identity (Bhatia and Ram 2001). In this article, we examine how both the individual- and the group-level processes of cultural change relate to individual levels of traditional ecological knowledge. We depart from research using unidimensional proxies of cultural change (such as fluency in the national language, schooling, or number of visits to the closest local town (Dressler, et al. 1998; Gross, et al. 1979; Sternberg, et al. 2001) and use multidimensional scale that proxies for individual cultural change. Furthermore, we use cultural consensus analysis to construct a village integral aggregate variable (*sensu* (Jaskyte and Dressler 2004), that captures information that exclusively describes village's properties. Differentiating between the individual and the supra-individual processes of cultural changes can shed light into the pathways through which cultural change affects individual levels of knowledge.

2 Case study

Our case study draws from research among the Tsimane', an indigenous group native to the Bolivian Amazon. Despite having been contacted by Jesuit missionaries more than 300 years ago (Reyes-Garcia, et al. 2012a), the Tsimane' remained relatively isolated from Western influence until the mid-20th century. Escaping from the violence of the colonial period, the Tsimane' confined themselves to the upper parts of the Apere and the Maniqui Rivers, where they lived in small, scattered, and mobile villages subsisting on hunting, fishing, and the gathering of wild plants. Their rejection to missionaries, cattle ranchers, and other newcomers is reflected in the ethnographic literature depicting the Tsimane' as an elusive ethnic group (Chicchon 1992; Nordenskiold 1924).

The relative, and partially chosen, isolation of the Tsimane' forcibly ended in the 1950s, when the construction of new roads, the logging boom, and the arrival of a new wave of missionaries and highland colonist farmers put the Tsimane' into continuous contact with

different segments of the Bolivian society, a process that gradually transformed the world in which the Tsimane' lived (Chicchon 1992; Godoy, et al. 2005b; Reyes-Garcia, et al. 2012a). Changes in Tsimane' ways of life are today evident at the economic and the social levels.

At the economic level, for instance, although the Tsimane' continue to be fairly autarkic (mostly relying on subsistence activities such as hunting, foraging, and shifting agriculture), there is increasing variation in their dependence on subsistence- and market-oriented economic activities (Vadez, et al. 2008). Thus, while some Tsimane' are still very dependent on traditional subsistence activities, other are becoming dependent on cash cropping, selective logging, or on employment as unskilled laborers in logging camps, cattle ranches, and in the homesteads of colonist farmers (Reyes-García, et al. 2012; Vadez, et al. 2008).

At the social level, Tsimane' traditional norms and mores are also gradually changing. Thus, contact with the national society in general, and with the missionaries in particular, has changed family structure among the Tsimane'. For example, polygamy has been replaced by monogamy in nuclear households (Daillant 2003). The traditional practice of cross-cousin marriage continues to be common, although not unique. The Tsimane' society was typically organized around the extended family, within which labor and food were shared. Villages were composed of extended family clusters, but migration between villages was frequent with high levels of visiting and sharing among members of different households. During those events, visitors gathered around to drink home-fermented beer and to talk about hunting, fishing and other activities. Experiences, tales, myths, stories, songs and other cultural codes are shared on such occasions. Male temporary migration to logging camps and ranches largely affect such model, both regarding the modes of subsistence but also household alliances and patterns of visiting and sharing.

Like other small-scale societies, the Tsimane society was fairly egalitarian. Traditionally, the socio-political authority was hold by shamans (locally known as *cocojsi*) and elders. Tsimane' *cocojsi* and elders were respected and deferred to for their knowledge of animals, plants, and locations of hunting grounds and sacred places. They were also respected for their knowledge of traditional norms, stories and myths, family lineage histories and past events, and ethics for living in accordance with the spirit-world. The authority of the elders has being formally replaced by a new political system that grants the representative power to young people, who are able to communicate in Spanish. However, those chiefs (*corregidores*) have little to no coercive authority and their main tasks are to hold and conduct meetings in the event of conflicts, help organize community labor events, and represent village interests in meetings with outsiders.

For most Tsimane', the intensity and frequency of exposure to non-Tsimane' has specially increased since 2006, when Bolivia started a new political era with the arrival to the presidency of an indigenous leader, Evo Morales. Indeed, policies enacted after 2006 have intensified Tsimane' exposure to the non-Tsimane' world including a new agrarian reform that distributed forests around the Tsimane' territory to highland colonist farmers; an education reform that brought non-Tsimane' teachers and a Spanish-taught curriculum to Tsimane' schools; cash-transfers to subsidize education and health, which need to be

collected in local towns; and the construction of some new basic service infrastructures in Tsimane' villages.

Our previous research suggests that the Tsimane' traditional knowledge system is also changing. In recent work we found that between the period 2000-2009, Tsimane' adults experienced a net decrease in the report of plant uses ranging from 9% to 20% (Reyes-García, et al. 2013a), although a finer analysis suggests that different domains of knowledge could be following different secular trends (Reyes-García, et al. 2013b). Our research is less conclusive about the drivers of such change. In previous studies we have analyzed the association between an individual's level of wild plants knowledge and their integration into the market economy and level of schooling. We have found that people who live far from the market-town share more traditional knowledge than people who live closer to town (Reyes-Garcia, et al. 2005), and that only market-related activities that take people out of their environment and cultural context have a negative effect on their traditional knowledge (Reyes-Garcia, et al. 2007b). We have also found that, although the number of years of schooling bears a negative association with traditional ecological knowledge, the magnitude of the association is low, probably because until recently, schooling was of low intensity and partially a contextualized activity (i.e., few hours, in Tsimane' language, using examples from the local environment, and with Tsimane' teachers) (Reyes-Garcia, et al. 2010).

In sum, previous research suggests that a) interactions between the Tsimane' and other sectors of the Bolivian society are rapidly increasing, although there is heterogeneity regarding how different individuals engage in those interactions; b) when compared to baseline levels, Tsimane' traditional ecological knowledge seems to be eroding; and c) none of the two drivers of traditional knowledge change analyzed in previous research (individual economic change and schooling) seem to fully account for those changes. Altogether, our previous findings call for further research on the association of cultural change and traditional knowledge among the Tsimane'.

3 Methods

Three PhD students collected data during the years 2008 and 2009 through individual-level interviews lasting about one hour/person. Data were collected in coordination with the Tsimane' Amazonian Panel Study (TAPS). Four Tsimane' who have worked with TAPS from its inception (1999) served as translators. Free prior, informed, written consent was obtained from the *Gran Consejo Tsimane'* (the Tsimane' political authority) and informed oral consent was obtained from village leaders and all participants.

3.1 Sample

Unofficial figures estimate the Tsimane' population at about 12,000 people settled in about 125 villages along riverbanks and logging roads in the SW of the department of Beni (*Gran Consejo Tsimane'*, personal communication). We used a recent village census (Reyes-Garcia, et al. 2012a) to select Tsimane' villages settled at different distances from a main road or market town (n=67). In villages with 10 or less households we surveyed one adult in each household; in villages with 11-40 households we randomly selected 10 households from a list provided by the highest-ranking authority; and in villages larger than 40

households we randomly selected 25% of the households for interviewing. We limited data collection to men for convenience, as the interviews were done in the context of a larger action-research project that focused on men (Reyes-Garcia, et al. 2012b). Since several authors have suggested that the accumulation of traditional ecological knowledge likely peaks in the late teens and remains relatively constant afterwards (Hunn 2002; Zarger 2002), we restricted our analysis to people aged 16 or older. Given that our analysis includes village aggregates, we deleted from the samples villages where we could interview less than 5 people. The final sample consists of 484 Tsimane' men from different households living in 47 communities (Fig.1).

3.2 Plant use knowledge

From the many domains of traditional ecological knowledge, we limited our research to plant use knowledge. While this measure does not include all the traditional knowledge of a group, it is a commonly used proxy (e.g.,(Camou-Guerrero, et al. 2008; Dovie, et al. 2008; Giovannini, et al. 2011) for traditional ecological knowledge). Following a standard practice (see (Reyes-Garcia, et al. 2007a) for a review), we measured variation in individual levels of plant use knowledge by evaluating responses to a questionnaire of useful plants. For each of the 20 randomly selected plants in our list, we asked every informant whether the plant could be used for medicine, food, firewood, canoe building, and/or house building. We counted various uses within one domain as one use (e.g., several medicinal uses of a plant). To assign a plant use knowledge score to each informant, we first elaborated an answer-key to our questionnaire which considered as correct those plant uses that had been mentioned by at least 10% of people in the sample. In the second step, we compared individual matrices of responses to the generated answer-key, assigning one point to each positive match. Thus, our overall measure of plant use knowledge consists of the sum of all positive matches between an informant's response and the generated answer-key.

3.3 Individual-level cultural change

We followed a long tradition in cross-cultural research and used a bipolar multidimensional scale that proxies for individual cultural change (Cuellar, et al. 1980; Olmedo 1979; Padilla 1980; Szapocznik, et al. 1978). We selected eight topics that capture traditional Tsimane' beliefs and values (Huanca 2008) and elaborated one question per topic (Table 1). Questions were presented in the form of a ladder with five steps and two scenes, one at the bottom and one at the top. The scenes represented a "traditional" vs. a "modern" Tsimane'. Respondents were asked to indicate where they would place themselves somewhere along the ladder. For each respondent, we randomized the location of the "traditional" and of the "modern" scene. After unrandomizing answers, we used a measure of reliability (Cronbach's alpha coefficient) to test for the internal consistency between answers to the eight questions. Since variables were positively associated with each other (see Results), we assumed that they measure parts of the same construct and added responses to the eight questions to create a new variable that we named *detachment to tradition*, for which lower scores indicate more closeness to traditional Tsimane' beliefs and values.

We also collected information on three standard unidimensional proxies of individual cultural change: fluency in the national language (Spanish), schooling, and number of visits

to the closest local town (Dressler, et al. 1998; Gross, et al. 1979; Sternberg, et al. 2001). We assessed informants' Spanish fluency during interviews, discriminating between informants who could answer the survey in Spanish and those who could not. We also asked informants to report the maximum grade they had completed in school and to recall the number of times they had visited the main market town during the previous year.

3.4 Village-level cultural change

We followed (Jaskyte and Dressler 2004) and used cultural consensus (Romney, et al. 1986) to construct two village-level measures of cultural change. Cultural consensus analysis performs a factor analysis of cases across questions. From this analysis we retained two measures: 1) the ratio of the first to the second eigenvalue, also known as cultural consensus and 2) the average of the loading of an individual on the first factor, known as cultural competence. The measures were constructed for each village and constitute integral aggregate variables (Jaskyte and Dressler 2004), thus capturing information that exclusively describes village's properties. To calculate *cultural consensus* we used the interval-level option in consensus analysis in the ANTHROPAC software because the items were rated on a five-point scale.

We also collected information on another standard proxy variable for village cultural change: village accessibility to the nearest market-town. To do so, we first created an index of *remoteness* by adapting the formula proposed by (Eisenberg, et al. 2006). We calculated the village distances to the nearest market-town using GPS readings collected at the village center. We also recorded the monetary cost of traveling to the nearest market town. We used those two values to calculate a rank of remoteness for each village by averaging normalized values of distance and cost.

3.5 Control variables

We collected data on control variables that previous research suggests that may affect the distribution of knowledge within a group. Such variables include age (and age square to control for possible non linearity), household size, and integration into the market economy. Integration into the market economy was proxied with two variables: i) Bolivianos (the Bolivian currency) obtained from the sale of rice since last harvest (US$1=7.2Bolivianos, average during the study period) and ii) Bolivianos earned from wage labor during the three months before the interview.

3.6 Data analysis

To explore the association between individual- and village-level cultural change and plant use knowledge we conducted bivariate and multivariate analyses. We used Spearman correlations to evaluate the relations between individual and village proxies for cultural change and individual levels of plant use knowledge. For the multivariate analysis we run two separate regressions. The first regression is represented by the following expression:

$$\mathrm{TEK}_{ihv}=\alpha+\lambda \mathrm{D}_{ihv}+\gamma \mathrm{ICC}_{ihv}+\psi \mathrm{C}_{ihv}+\varepsilon_{ihv} \quad [1]$$

Where TEK_{ihv} stands for the plant use knowledge score of participant *i* of household *h* and village *v*; D_{ihv} is the *detachment index* of the same individual; ICC_{ihv} is a vector of unidimensional variables that previous authors have used as proxy variables for cultural change (i.e, Spanish fluency, schooling, and travel-to-town frequency); C_{ihv} refers to our control variables (i.e., age and household size). ε_{ihv} is a random error term.

Since the individual and the supra-individual processes of cultural change can both operate at the same time, in our next two models we added village level variables. Specifically, in our second and third models we alternatively included our integral aggregate variables, that is, cultural consensus and average village cultural competence. In all models we used clustering by village of residency.

We expected the coefficient of the individual *detachment index* (λ), to be negatively associated with levels of plant use knowledge irrespective of other proxy measures for cultural change. If the association between cultural change and plant use knowledge occurs mainly through individual-level processes, then we would expect a large and statistically significant coefficient for the individual *detachment index* in all the models. However, if the association between cultural change and plant use knowledge occurs mainly through village-level processes, then we would expect a small and statistically significant coefficient in the individual index once we include village-level variables in the model. For the statistical analyses we used ordinary least square regressions with robust standard errors. Statistical analyses were performed with Stata software.

4 Results

4.1 Descriptive statistics and bivariate analysis

Unrandomized responses to the eight questions that compose the detachment index had a mean value close to the midpoint of 2 (between 1.39 and 1.93) (Table 1). The standard deviation of responses to all the questions was relatively high (the lowest SD was of 1.28), suggesting large variation on the cultural orientation of informants. Results from Cronbach alpha suggest that there is internal consistence in the scale used to evaluate Tsimane' cultural orientation, as all the items were positively associated one to each other. However, the alpha coefficient was below the standard 0.80 (α=0.70).

The average number of uses for the 20 selected plants was of 22.75 uses (SD=6.89), a little above one use per species. The respondent who mentioned a lower number of plant uses referred 7 uses, whereas two of the respondents mentioned 47 uses. On a range from 0 to 32, the average score in our *detachment index* was 13.54 (SD= 6.37) slightly under the midpoint (Table 2). There is a considerable range of variation in the degree to which each village share the attachment to the selected set of values. The ratio of the first to the second eigenvalue, a major indicator of degree of sharing, had a range from 1.02 to 4.13. Only in three villages was this ratio above 3, the standard threshold that indicates cultural consensus. The average cultural competence had a mean value of 0.25, but a very large range between 0.001 and 0.71.

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We found a negative and significant correlation between the individual detachment index and plant use knowledge (Fig. 1). The bivariate analysis suggests that villages that shared their level of attachment to cultural values had higher average plant use knowledge, although this association was not statistically significant (Fig. 2). However, we also found that villages with higher average cultural competence also had higher average plant use knowledge (Spearman's rho = 0.43; p=0.002).

4.2 Multivariate analysis

In the first model ([A]), the detachment index has a negative association with the plant use knowledge score. The association is statistically significant even after controlling for other unidimensional proxies of cultural change (schooling, travel to town, Tsimane' monolingual) and other control variables. In other words, results from model [A] suggest that the more detached from traditional Tsimane' beliefs and values a person is, the less plant uses the person knows. However, the real effect of this association was low, as the decrease of one point in the detachment index (that ranges from 0 to 32) was associated with 0.19 less plant uses reported (p=0.006). From the three unidimensional proxy variables for cultural change included in the model, only travel to town was associated with plant use knowledge: people who traveled less to town had higher plant use knowledge scores.

In model [B] we re-estimated the associations, by including cultural consensus. Results from models [A] and [B] differ in two main ways. First, although in model [B] the individual *detachment index* remains associated with plant use knowledge, the coefficient is slightly smaller than in model [A]. Moreover, the variable cultural consensus bears a positive and statistically significant association with the individual plant use knowledge score, indicating that individuals who live in villages where there are higher levels of consensus on responses on attachment to cultural values tend to have higher plant use knowledge than individuals who live in villages where there is less agreement. Other variables remained mostly unchanged, except travel to town, variable that lost statistical significance. Second, the overall explanatory power of this model is larger than for the previous: the R^2 increased from 0.10 in model [A] to 0.15 in model [B].

In model [C] we re-estimated the association presented in model [B] but this time including our second integral aggregate variable, village average cultural competence. As in previous models, in model [C] the association between the individual *detachment index* and plant use knowledge remains statistically significant. The village average cultural competence also shows a positive, large, and statistically significant association with individual plant use knowledge. Furthermore, the overall exploratory power of this model is larger than for previous models (R^2=0.20).

5 Discussion

In this article, we have examined how individual and village attachment to traditional beliefs and values (a proxy of cultural change) relate to individual levels of plant use knowledge, our proxy for traditional ecological knowledge. We have found that both the individual level of detachment to traditional values and the village level of agreement in detachment to traditional values are negatively associated with individual levels of plant use knowledge.

Because both the individual- and the village-level variables bear statistically significant associations with plant use knowledge, our results suggest that the mechanisms linking attachment to traditional believes and values and plant use knowledge operate through the individuals but also through larger social units, villages in our case.

On the one side, there are at least two plausible mechanisms linking individual detachment from traditional beliefs and values and individual plant use knowledge. First, individuals who are more detached from traditional beliefs and values might be more likely to have changed their lifestyles, including the shift from subsistence to cash-oriented economic activities. Access to cash provides people with the opportunity to access market products, from foods to medicines, or tools, most of which substitute products that were previously plant-based. Such a shift might be associated with the loss of plant use knowledge, as it renders this knowledge irrelevant for those individuals who can access and afford ready-made market-substitutes.

Second, individuals more detached from traditional beliefs and values might have accepted standard stereotypes stigmatizing indigenous cultures, including their own, as backward and obsolete and needing development and modernization. The interiorization of such stereotypes might affect plant use knowledge as individuals holding such view of their own cultures might consider plant use knowledge backward and useless. So, they might consider that this knowledge is not worth to learn, or even if they still partially hold it, they might consider not worth reporting.

On the other side, the mechanisms through which cultural transmission operates provide a convincing explanation for the association between village levels of agreement on traditional beliefs and values and individual levels of plant use knowledge. Cultural transmission refers to the process of social reproduction in which the culture's technology, knowledge, behaviors, language, and beliefs are communicated and acquired within a defined cultural group (Cavalli-Sforza and Feldman 1981; Hewlett and Cavalli-Sforza 1986). Cultural transmission occurs through several pathways, including the copying of the beliefs or practices of the majority, know as conformist transmission (Richerson and Boyd 2005). To copy the majority, although not always adaptive, overall allows individuals to short-cut the costs of individual learning and experimentation. Thus, under situations of high social agreement, individuals tend to follow conformist transmission and copy the most common behavior and body of knowledge (Richerson and Boyd 2005). An important implication of conformist transmission is that when social agreement is high, there is also high fidelity in the knowledge transmitted. However, when social agreement is low, individuals are exposed to alternative sets of knowledge. Lacking clues on which is considered culturally correct might increase the chances that those individuals resorts to own learning and experimentation for the acquisition of knowledge, which consequently deprives them from the benefits of social learning.

Thus, lack of village agreement on the importance of traditional beliefs and values might affect individual levels of plant use knowledge by reducing individuals' chances to benefit from cultural transmission and simply using conformist transmission. Given that the acquisition of cultural knowledge –such as plant use knowledge- is a social process,

situations of low cultural agreement have profound implications for individual knowledge acquisition. This is not to say that individuals do not have any level of agency on the amount of traditional ecological knowledge they might acquire, but rather to acknowledge that this agency is not complete, because the acquisition of traditional ecological knowledge is a social process. In villages where there is more consensus on the culturally correct beliefs and values to follow, specific individuals have a defined body of knowledge (including plant use knowledge) from which to socially learn. In contrast, in villages where there is no agreement on the culturally correct beliefs and values to follow, individuals are exposed to different cultural models and associated bodies of knowledge, which probably increases the chances that they resort to own learning, potentially experimenting with different bodies of knowledge.

Before concluding, we note that our study suffers from one important limitation. We measured individual cultural change by using a bipolar scale with elements of the 'traditional' Tsimane' culture at one end and a corresponding item highlighting change at the other end. By placing the two elements in a continuum, our measure assumes that the selection of one element necessarily decreases the selection of the other. A recent review of psychometric scales notices that bipolar scales do not capture well orthogonal cultural identity, which is better captured with bilineal measures (i.e., using two independent unipolar scales that avoid the zero-sum presumption of bipolar scales but that allow to test the sign of the correlation between them). Thus, future research attempting quantitative measures of cultural change among indigenous peoples should use bilineal measures to better capture phenomena such as hybridization and orthogonal cultural identification among indigenous peoples.

6 Conclusion

Since Berry and colleagues (1986) noticed that the process of cultural change occurs not only at the group but also at the individual level, many studies have addressed individual variation in cultural change. Results from that research have suggested that individuals have certain degree of agency in the process of cultural change, as they can partially decide how much and in which way they want to adopt new cultural models (Berry 1999; Freire 2007). In this research we have found that the variable that captures the aggregate level of agreement on the valuation of traditional Tsimane' beliefs and values is also associated with individual plant use knowledge. This finding highlights the importance of an intermediate unit of analysis that lies between the individual and the society to explain the evolution of the process of cultural change. In the case presented here, this intermediate level is represented by villages *within* the same ethnic group.

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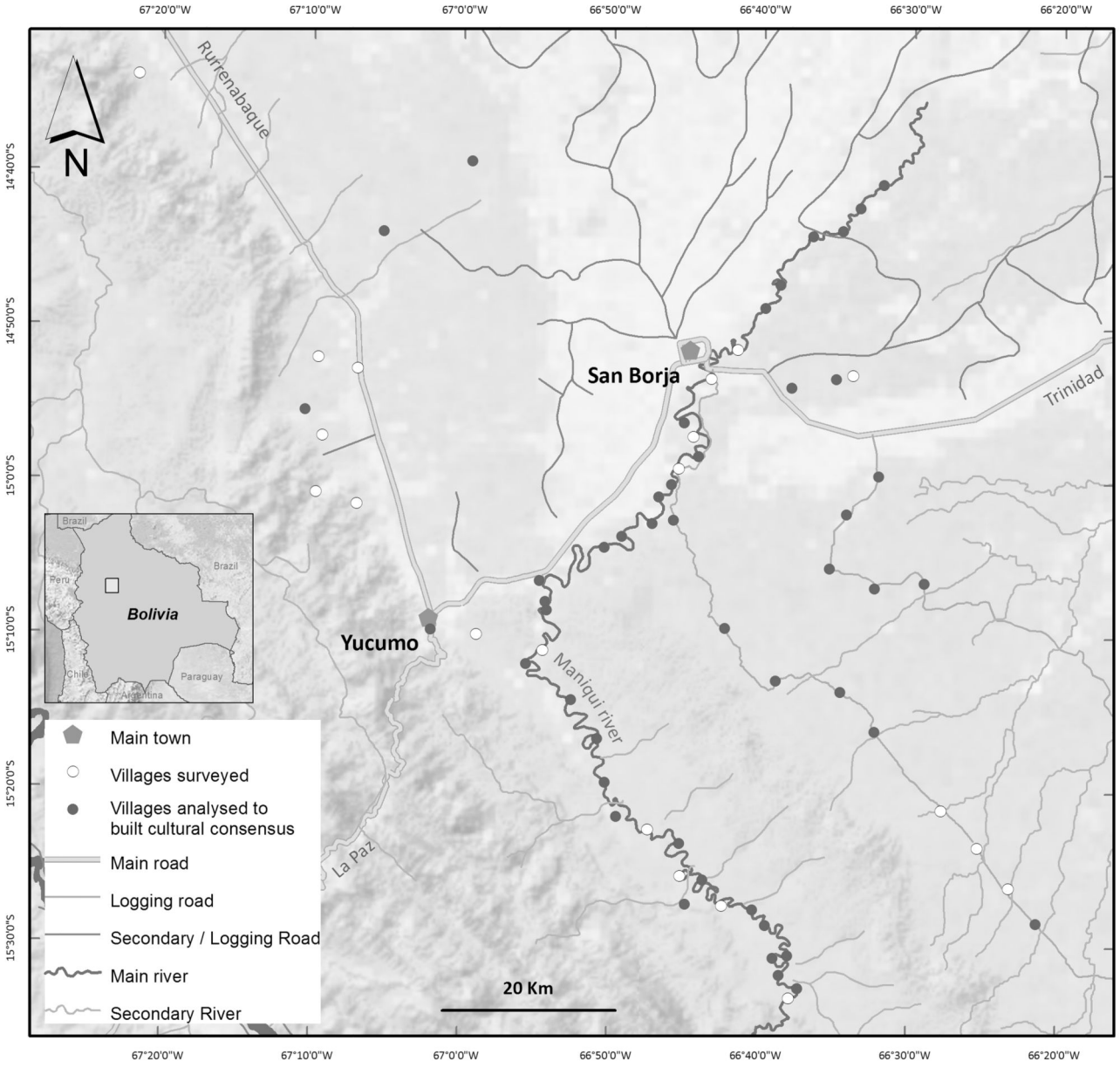

Figure 1.
Map of the studied villages.

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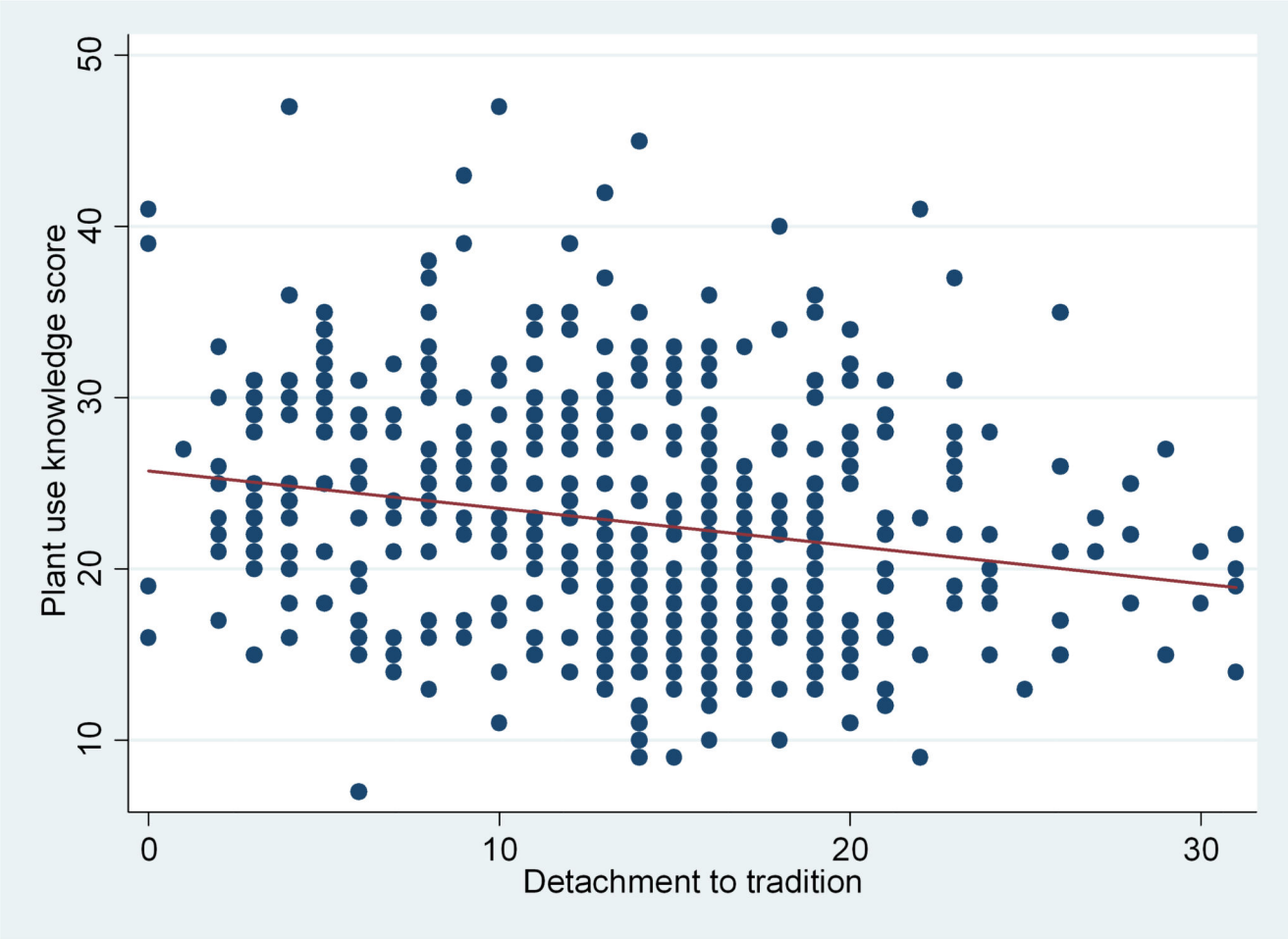

Figure 2.
Correlation between individual detachment to tradition and plant use knowledge (Spearman's r=-0.21, p<0.001, n=484).

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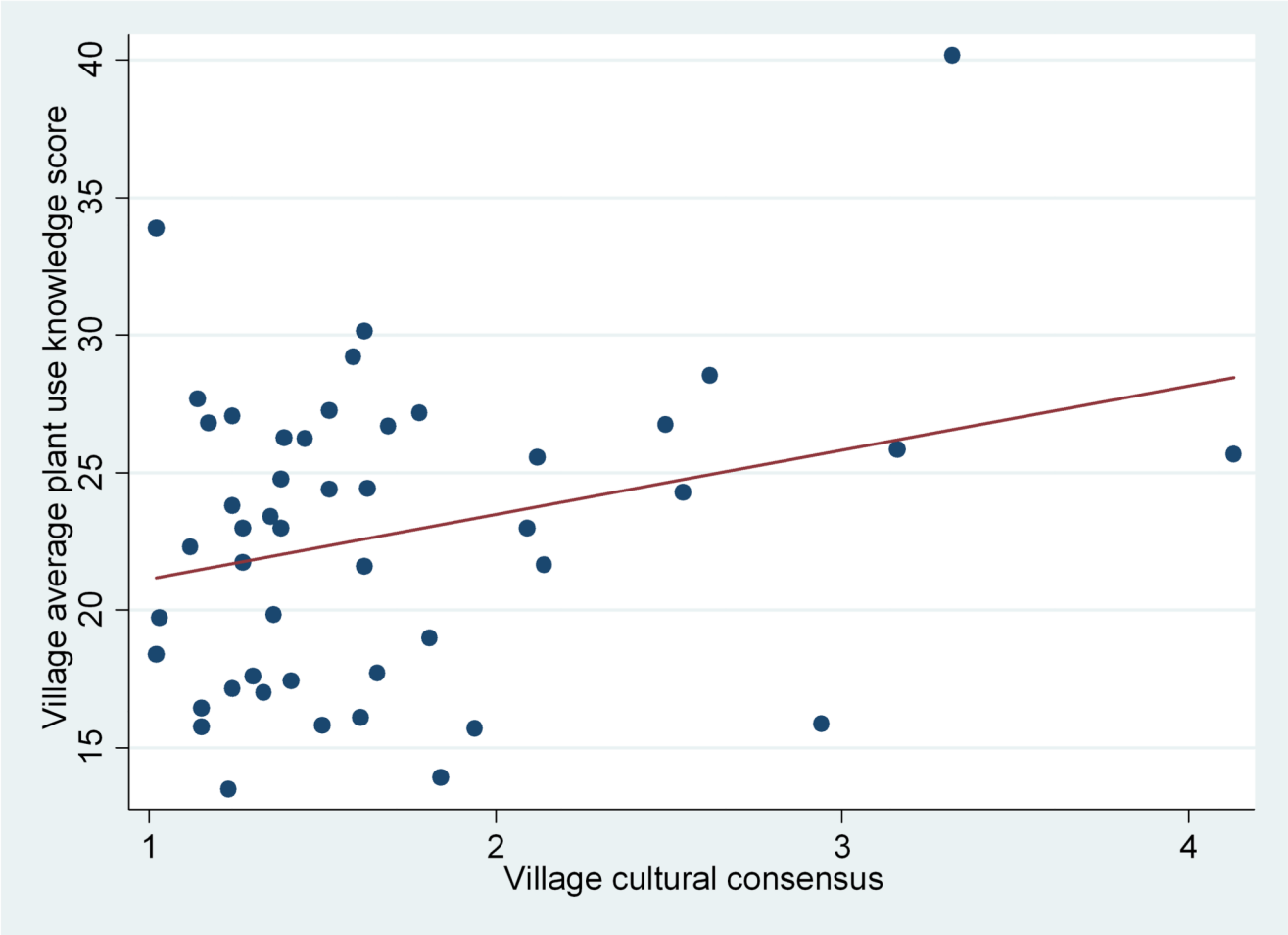

Figure 3.
Correlation between village cultural consensus in detachment to tradition and village average plant use knowledge (Spearman's r=0.17, p=0.26, n=47).

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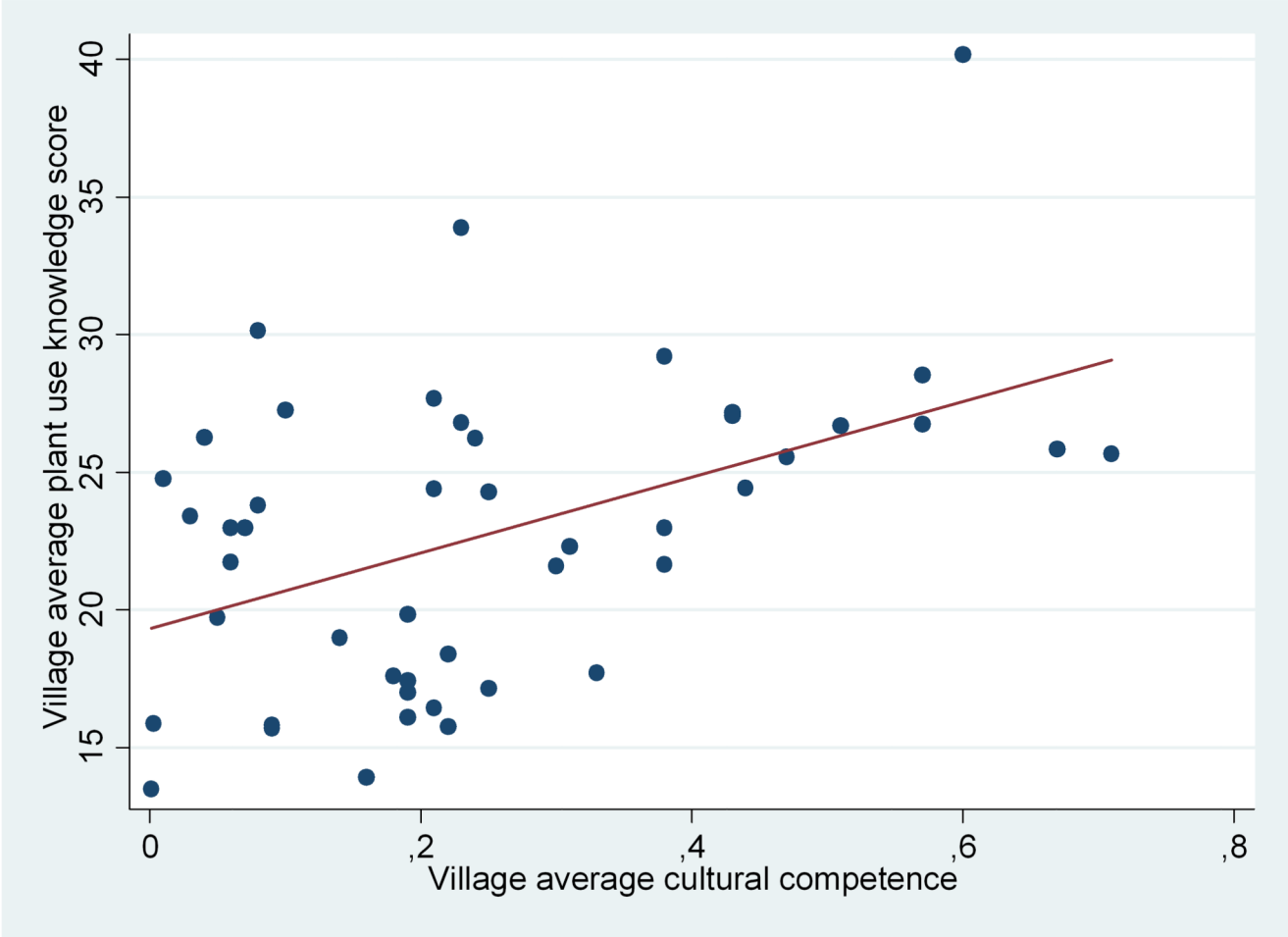

Figure 4.

Correlation between village average cultural competence in detachment to tradition and village average plant use knowledge (Spearman's r=0.43, p<0.002, n=47).

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Table 1

Descriptive statistic of the values given by respondents to the questions which form the *detachment index* (n=484). Questions rated on a scale of 0 (attached to traditional Tsimane' cultural value) to 4 (detached from traditional Tsimane' cultural value).

	Question[a]	Mean	SD
I	Elders in upriver villages work a lot in their agricultural fields, but the Tsimane' living in the town prefer working for loggers and do not so much in their fields. How important is it for you to work in the fields? Where would you put yourself on the ladder?	1.41	1.28
II	For elders in upriver villages it is important that their children marry their cross-cousin. For the Tsimane' living in town it is not important that their children marry their cross-cousin. How important is it for you that your children marry their cross-cousin? Where would you put yourself on the ladder?	1.39	1.52
III	Elders in upriver villages like to fish communally with plant poison (*barbasco*), but Tsimane' living in town rarely fish communally with plant poison. How important is it for you to fish communally with plant poison? Where would you put yourself on the ladder?	1.60	1.28
IV	When the elders in upriver villages plant manioc, they do not touch their hair to ensure the good growth of the plant, but Tsimane' living in town do not follow this custom. How important is it for you to follow this custom? Where would you put yourself on the ladder?	1.70	1.43
V	When elders in upriver villages get sick, they cure themselves with plants; but when the Tsimane' living in town get sick, they cure themselves with drugs from the pharmacy. Do you prefer to cure yourself with plants or with drugs? Where would you put yourself on the ladder?	1.80	1.39
VI	For elders in upriver villages it is important to share *väij* (*Bactris* sp. fruits), but the Tsimane' living in town rarely share *väij*. How important is to share *väij* to you? Where would you put yourself on the ladder?	1.81	1.47
VII	Elders in upriver villages think that if their bow breaks, they will have bad luck, but the Tsimane' living in town do not believe a broken bow brings bad luck. Do you think when your bow breaks something bad is going to happen to you? Where would you put yourself on the ladder?	1.90	1.40
VIII	Elders in upriver villages ask for permission to the spirit of large trees before cutting down a tree, but the Tsimane' living in town do not think it is important to ask for permission to the spirit of a trees before cutting it down. How important is it for you to ask permission to the tree spirit before cutting down a tree? Where would you put yourself on the ladder?	1.93	1.49

[a]Questions are based on ethnographic information collected by Huanca (2008).

Table 2

Definition and summary statistics of dependent and control variables used in multiple regressions (n=484).

Variable	Description	Mean	SD	Min	Max
	Dependent variable (n=484)				
Plant Use knowledge	Total number of uses known for 20 plants randomly selected	22.75	6.89	7	47
	Individual-level cultural change(n=484)				
Detachment index	Total score from eight questions about cultural orientation (from 0 to 32, where lower numbers indicate more closeness to traditional Tsimane' values)	13.54	6.37	0	31
Schooling	Maximum years of formal schooling (from 0 to 13)	2.06	2.74	0	13
Travel to town	Number of trips to the main town over the previous 12 months	17.05	21.26	0	288
Spanish fluency	Percentage of informants monolingual in Tsimane'	7.44		0	1
	Village-level cultural change (n=47)				
Cultural consensus	Village cultural consensus in ratings to the detachment index variable	1.69	0.66	1.02	4.13
Average cultural competence	Village average cultural competence	0.25	0.19	.001	0.71
Village-to-town distance	Linear distance (km) from the village to the closest market town	48.56	33.93	1.56	122.9
	Control variables (n=484)				
Age	Person's age, in years	40.91	16.20	17	83
Rice sales	Bolivianos obtained from the sale of rice since last harvest (US$1=7.2Bs, average during the study period)	632	894	0	6000
Wage from loggers	Bolivianos earned by the subject from wage labor with loggers during the three months before the interview	93	314	0	3500
Household size	Number of people living in the household	5.93	2.73	1	17

Table 3

Covariates of plant use knowledge among Tsimane' indigenous peoples (n=484).

	Models		
	[A]	**[B]**	**[C]**
Cultural change			
Detachment index	-.194*** (.048)	-.149** (.061)	-.153** (.060)
Schooling	.064 (.098)	.172 (.125)	.222* (.123)
Travel to town	-.059*** (.017)	-.048* (.024)	-.053** (.024)
Tsimane' monolingual	-1.514 (1.073)	-1.845 (1.31)	-1.46 (1.12)
Cultural Consensus	^	2,38* (1.30)	^
Average cultural competence	^	^	11.6*** (3.39)
Remoteness	^	.547 (.424)	.371 (.406)
Control			
Age	.153 (.118)	.161 (.078)	.171* (.104)
Age square	-.001 (.001)	-.001 (.001)	-.001 (.001)
Rice sales	-.0001 (.0003)	.0001 (.0004)	.0002 (.0004)
Wage from loggers	.0007 (.0007)	.0009 (.0008)	.0008 (.0007)
Household size	.222* (.116)	.172 (.115)	.171 (.114)
R^2	0.10	0.15	0.20

[A] Model without controls for village effects. [B] Model including village cultural consensus. [C] Model including average cultural competence. All models are OLS regressions with robust standard errors (in parenthesis) and adjusted for clustering on village of residency. Regressions include constant (not shown). *, **, and ***: statistically significant at the 90%, 95%, and 99% level, respectively.