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Information transmission and the oral tradition: Evidence of a late-life service niche for Tsimane Amerindians

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Abstract

Storytelling can affect wellbeing and fitness by transmitting information and reinforcing cultural codes of conduct. Despite their potential importance, the development and timing of storytelling skills, and the transmission of story knowledge have received minimal attention in studies of subsistence societies that more often focus on food production skills. Here we examine how storytelling and patterns of information transmission among Tsimane forager-horticulturalists are predicted by the changing age profiles of storytellers' abilities and accumulated experience. We find that storytelling skills are most developed among older adults who demonstrate superior knowledge of traditional stories and who report telling stories most. We find that the important information transmitted via storytelling typically flows from older to younger generations, and stories are primarily learned from older same-sex relatives, especially grandparents. Our findings suggest that the oral tradition provides a specialized late-life service niche for Tsimane adults who have accumulated important experience and knowledge relevant to foraging and sociality, but have lost comparative advantage in other productive domains. These findings may help extend our understanding of the evolved human life history by illustrating how changes in embodied capital predict the development of information transmission services in a forager-horticulturalist economy.

Keywords

Oral tradition; Information transmission; Storytelling; Expertise; Development; Life history theory

> "When Dojity arrived at Micha's house, Micha started to lose faith in him. Dojity stole his wife and fled up the Maniqui river with her. People heard of the theft and wanted to kill Dojity. Hearing this, he dressed in very old rags to disguise himself. When people saw him dressed so poorly, they asked: "When is Dojity coming?".

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Appendix A, B, and C. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.evolhumbehav.2017.10.006.

> And Dojity would answer: “He is on his way, he is well dressed and will be here soon.” Dojity went on and then blew to turn these people into chuchio and tacuara for making arrows, and also into porcupines and iyopo trees. Dojity continued walking and headed upriver on the Maniqui, where the woman he had stolen finally gave birth. There Dojity transformed the woman into salt and her amniotic fluid turned into the Pachene salt springs that feed the Pachene River.”
>
> [-translated from Mayer and Clemente's (2000) version of *Dojity y Micha*]

1. Introduction

Before written language, mass printing, and electronic broadcast, cumulative traditional ecological knowledge (TEK) “about the relation of living beings (including humans) with one another and with their environment” was largely transmitted across generations using oral traditions (Berkes, Colding, & Folke, 2000: 1252). Across cultures, storytelling and music continue to play central roles in traditional education (Scalise Sugiyama, 2001). Stories and songs often encode fitnessrelevant information about hazards, subsistence, morality, mythology, norms, marriage and relationships (Scalise Sugiyama, 1996). For example, most human subsistence skills require cumulative knowledge that is often transmitted from older to younger generations. Without effective information transmission, complex skill development using only individual learning and effort would be very difficult or impossible (Boyd & Richerson, 1985). Skilled communicators in the oral tradition can make difficult-to-acquire information salient, memorable, and amenable to re-transmission, helping individuals develop the complex skills they will need in adulthood (Rubin, 1997). Stories also provide listeners opportunity to engage in low-cost “cognitive play” as they imagine beliefs and desires of other minds, and simulate problems (Boyd, 2009). For example, traditional stories often feature solutions to unpredictable or rare events and potentially deadly problems (e.g. natural hazards, predators, adversarial conspecifics) that are of great importance but can be costly to discover through first-hand experience (Coe, Aiken, & Palmer, 2005a; Coe & Palmer, 2008). Independent of information value, stories and music are entertaining – providing a social lubricant among kin that can reinforce ties, mitigate conflicts, and improve gains from cooperation (Boyd, 2009; Coe & Palmer, 2008; Steadman & Palmer, 1997).

Social and ecological context may affect who tells stories and performs music and who learns from performances. Ethnographic accounts of subsistence societies often portray skilled storytellers and musicians as older adults or grandparents (e.g. Biesele, 1993; Hallowell, 1992; Simmons, 1945). Describing Yakutat Tlingit hunter-gatherers, de Laguna (1997, p.839) writes, “when an informant indicated how he or she had learned myth or legend it was from a grandmother or grandfather, less often from a father or mother”. Though only a small percentage of the population, these “active bearers” are responsible for maintaining the oral tradition by intergenerational transmission (Acerbi, Kendal, & Tehrani, 2017; Coe & Palmer, 2008). While storytellers and musicians from traditional societies have been characterized as mostly older specialists (Archibald, 2008; Hale, 1998), little

empirical evidence is available to support claims that oral tradition is learned from the oldest generations.

Much of what is known about narrative and musical skill development concerns economically advanced society, where a different pattern is described: according to Miller (1999), peak ages for popular music production (females 29, males 33 for rock; females 39, males 30 for jazz) and literature (females 50, males 43) coincide more with reproductive and parenting ages. Economically advanced society offers young adults more specialized career path options, while most people of the same age and sex have the same common skills and do the same work in traditional subsistence society. By performing a large repertoire of stories and songs in ways that lower-fitness competitors cannot, storytelling and music specialists can broadcast honest signals (e.g. of intelligence and experience, sensu Miller, 2011) that might attract mates and allies. Economically advanced societies are also faced with rapidly changing problem sets (i.e., each generation faces many novel problems previous generations did not) that are better served by novel cultural solutions. Cultural evolution theory (e.g. Boyd & Richerson, 1985) suggests that *horizontal* (learning from peers) transmission will be preferred where a premium is placed on new solutions; suggesting that the role of culture transmitter in economically advanced society need not be restricted to older adults.

Here we examine the life course trajectory of skill development in the Tsimane oral tradition and patterns of information transmission attributed to this developmental process. We consider whether Tsimane storytelling is better understood as a *common* or *specialized skill*. Schniter, Gurven, Kaplan, Wilcox, and Hooper (2015) showed that most traditional Tsimane skills are developed by most adults. As a *common skill*, we would expect storytelling to be developed by most adults and to be positively associated with ability and expertise across other common skills and forms of productivity. As a *specialized skill*, storytelling is only undertaken by those who are at a comparative advantage to do so, and who otherwise may be losing fitness-enhancing value to coresident kin due to senescence-related declines in other domains of productivity (e.g. hunting, farming, food processing). Whether older adults are expert storytellers because of the long learning curve which they share with all others their age, or because they represent the select few in their age cohort who can realize a competitive advantage in the oral tradition over other skill domains, is of direct relevance to the idea of longevity evolving with selection against post-reproductive cognitive decline due to the value of older adults' accumulative knowledge (e.g. Schwarz et al., 2016).”

Among Tsimane forager-horticulturalists of Bolivia, the oral tradition has long served as a form of enjoyable cultural education tied to the important tradition of *sobaqui*, visitation with kin, neighbors and friends (Ellis, 1996). Tsimane storytelling occurs most often when it creates the fewest opportunity costs for transmitters and receivers: when people get together to visit, especially at small fireside family gatherings (de la De La Quintana & Daillant, 1999).[1] Prior to the introduction of formal schools and radios in the second half of the 20th century, the role of educator and entertainer fell on local experts, including *cocojsi* or shamans. Shamans have almost entirely disappeared from Tsimane culture. However,

[1]A similar pattern of fireside nighttime storytelling is reported among Ju/’hoansi (see Wiessner, 2014).

when vats of *shocdye*—a homebrewed manioc beer—are available, family and neighbors gather to drink communally. At family and community gatherings, older adults broadcast their knowledge by conveying details about memorable hunting trips, telling personal and traditional stories, interpreting dreams, and with *jimacdye*—instrumental music and song (Ellis, 1996; Iamele, 2001; Schniter, 2014). We further explain facets of Tsimane oral tradition in Section 1.1.

We consider how informants' age, story knowledge, abilities, and available audiences affect patterns of information transmission across the lifespan in a small-scale forager-horticulturalist society. Embodied Capital Theory (ECT) proposes that several unique features of the human life course are adapted responses to a skills-intensive, socio-ecological niche (Kaplan, Gurven, Winking, Hooper, & Stieglitz, 2010). Specifically, ECT hypothesizes that the life course of skill performance is shaped by characteristics of specific tasks (i.e. their difficulty, strength, motor dexterity, and knowledge requirements), the changing capabilities of individuals with age and experience, and the changing needs of the family budget (Bock, 2002a, 2002b; Crittenden, Conklin-Brittain, Zes, Schoeninger, & Marlowe, 2013; Gurven & Kaplan, 2006; Schniter et al., 2015). As adults become grandparents and advance through their post-reproductive years, physical declines in strength, endurance, and manual dexterity reduce the profitability of various types of food production. In response to these declines, older adults are expected to shift their efforts towards low-strength yet knowledge-intensive crafts and services. Schniter et al. (2015) showed that oral tradition skills (storytelling, music performance, and dream interpretation) increase with age (Fig. 1) and that older adults aged 60 through the mid-eighties are regarded by their peers as most expert in low-strength but knowledge-intensive skills, including those in the oral tradition (Table 1). Performances in the oral tradition (music and stories) bear characteristics making them optimal for a late-life service niche: they require extensive learning and support the childrearing, socialization, and subsistence goals distributed within and between multi-generational familial groups, yet do not require physical strength.

While oral tradition performance may benefit performers and audience members by transmitting TEK, cost-benefit tradeoffs may affect the likelihood of information transmission (de Backer & Gurven, 2006). Receivers show preference for transmitters they trust and information sources they consider more reliable, and in doing so develop preferences for specific performers, performance styles, and norms for who is allowed to perform (Pinker, 1997; Scalise Sugiyama, 1996). For example, audience members in traditional societies with sex-specific divisions of labor may have reasons to prefer performances by same-sex non-parental older kin. Tsimane demonstrate same-sex vertical transmission of ethnobotanical skills and knowledge attributed to their habit for same-sex socialization and a strong division of labor along sex lines (Reyes-García et al., 2009). In Australian, Melanesian, North American, Indian, and African societies, Radcliffe-Brown (1950) observed more egalitarian relations between older relatives (e.g. grandparents) and children than between parents and children. Others have since reported this pattern of privileged familiarity between “alternate generations” (e.g., Apple, 1956; Hewlett, Fouts, Boyette, & Hewlett, 2011; Lee, 2002). Older kin may be preferred for their greater lifetime experience (making them more trustworthy as reliable providers of honest and useful

traditional information) and fewer conflicts of interest (i.e., they share genetic interests, present little to no competition for mates or available alloparenting). Furthermore, same-sex older kin are often aware of youngsters' needs, making them well poised to enrich their narratives accordingly.

In this paper, we investigate story learning and storytelling among Tsimane forager-horticulturalists. After identifying 54 story-knowledgeable adults using the *Skills Survey* (Schniter et al., 2015), we surveyed them about their knowledge, telling and sourcing of 120 traditional Tsimane stories. We evaluate whether age patterns in reported knowledge and storytelling are consistent with predictions derived from ECT concerning the timing of skill maturation. We test whether storytelling is a *common skill* enabled by ability with other common skills, or whether storytelling is a *specialized skill* that people develop a comparative advantage in due to productivity declines with other skills. We also assess whether storytelling propensity is sensitive to the size and composition of potential audiences, consistent with a fitness-enhancing strategy. Finally, we evaluate whether reports of whom stories were learned from support a model of vertical, oblique, or horizontal oral tradition transmission.

1.1. Tsimane and their oral tradition

Tsimane (population ~ 16,000) are forager-horticulturalists inhabiting the southern reaches of the Amazon Basin in Bolivia. Although Tsimane were exposed to Jesuit missionaries in the late 17th century, they were never successfully settled into missions and remain relatively isolated from the larger Bolivian society, speaking their own language and little Spanish. Tsimane assume semi-sedentary residence in 90+ kin-based villages (with between approximately 50–150 people) that vary in river and road access, surrounding game densities, recent local deforestation, and access to market goods. Over 90% of the Tsimane diet derives from nonmarket sources (Martin et al., 2012). Tsimane subsistence stems primarily from adults' gardening, gathering, hunting, and fishing– activities that entail risks and complex extraction challenges. To meet these challenges, Tsimane transmit a rich body of knowledge to inform youngsters who eventually will master the necessary extraction techniques after decades of practice (see Table 1). Tsimane use their stories, music, and dream interpretation to assist with traditional knowledge transmission.

Stories are typically broadcast in group settings and tailored to audiences. In contrast with other forms of information transmission targeting individuals, stories do not typically involve visual examples, direct instruction, correction, or encouragement associated with various forms of skill instruction and pedagogy.

Tsimane retell traditional stories and tell of dreams and hunts. Storytelling is much less common than the musical performance or dream interpretation that the majority of adults 60 and older report. While only 5% of adults 15–29 years old tell stories, the proportion of storytellers is higher with age: 44% of oldest adults (60+ years old) tell stories (Fig. 1). Tsimane traditional stories show the same thematic elements consistently noted across populations: they communicate information about society, spatial knowledge, hazard avoidance, and local subsistence knowledge. In Appendix A and B, Tsimane myths are detailed that explain the origin of people, plants and animals, astral phenomena, and special

events (e.g. solar eclipse, wildfires, windstorms). Other traditional stories describe activities and ways of life important to Tsimane: horticulture (e.g., manioc, plantain, maize, tobacco, and cotton), making fire, obtaining salt, preparing and preserving meat, acquiring metal tools, marriage, sexual affairs, and murder.

The epigraph features a translation of a typical traditional Tsimane story, taken from a larger set of *Dojity and Micha* stories (see Appendix A for further translations). Dojity and Micha are Tsimane culture heroes responsible for creating the earth, and stories of their adventures fall into a large variety of recognized folktale categories including *hero tales, explanatory tales, animal tales, local legends,* and *jests* (see Appendix A). The epigraph is an example of a *hero tale* and an *explanatory tale* that features a *local legend*: Dojity, who had created people, turns some people into animals, others into plants (including those providing the woods and canes used by Tsimane for making bows and arrows), and yet others into recognizable features of the environment (salt and the springs feeding the Pachene river), giving them the identifiable characteristics that Tsimane now use. The story excerpt in the epigraph also has elements helpful for socialization: it describes a norm violation (absconding with a married woman) and the consequence of people's angry response (wanting to kill the norm violator).

Animal tales typically feature the travels, sexual pursuits, problems, and adventures of anthropomorphized characters, and may be used to socialize children by transmitting various social norms, morals, and respect for emotions (Coe, Aiken, & Palmer, 2005b). While wolves and foxes are prominent in European folklore, as coyote is in Native North American folklore, wild felines are commonly represented across Amazonian cultures. Tsimane oral tradition features many stories with wild feline characters (e.g. jaguar, puma, ocelot): unpredictable and dangerous predators that can silently stalk humans, perch in trees unnoticed, and that become increasingly active in low light conditions when they are harder to detect (Huanca, 2006). Some traditional stories address Tsimane beliefs that trees' *amo* (forest spirit guardians of plants and animals) have the power to transform into jaguars (especially when angered) and that clothes made from homespun cotton can transform into jaguars during a solar eclipse (Huanca, 2006), while other stories feature the jaguar character *Toyei*. Appendix B details 19 stories with felines, an additional 56 fables, and 5 stories about plant spirits (e.g., *O'ojpona, Úju, Opoj, Papajnaqui*).

Myths and songs about *amo* and their abodes correspond to knowledge about seasonality of and locations for hunting and fishing. For example, a specific alignment of the Milky Way (*Noco*) with respect to the Maniqui river as described in a myth, serves to indicate to Tsimane “the right time to use poison for fishing” (Huanca, 2006, p. 7). The traditional story survey includes three myths with *Noco* (detailed in Appendix B, described in Appendix A).

While the traditional stories have established core themes that are reliably transmitted from storytellers to listeners and ultimately from one generation to the next, other Tsimane stories are personal. Personal stories may include detail about one's dreams, personal relationships, and hunting adventures. For example, Tsimane hunters may “tell the hunt”, generating vicarious experiences for their audience, while displaying ability and knowledge.[2] While personal stories are not part of the oral tradition, their telling may be closely tied to it.

Personal information transmission is sometimes evoked by performances of traditional songs and stories mentioning wild animals or forest deities. For example, experienced hunters may volunteer elaborations about odors associated with, foods eaten by, and behavioral habits of specific animals, and confidently produce calls and vocalizations used to identify, manipulate, or describe them while providing thrilling narratives of challenges, dilemmas, and solutions to problems that they experienced.

As with storytelling skills, Tsimane also develop musical skills that are useful for effective pedagogy, communication, and entertainment. Musical performance includes instrumental music, traditional song, and improvisation. About 20% of adults 15–29 years old perform music but the proportion is higher with age: 55% of oldest adults (60+ years old) perform music (Fig. 1). Transcribed and translated examples of traditional and improvisational Tsimane songs are provided in Appendix A. When traditional melodies are played on flutes or violins in the absence of lyrics, they may serve as surrogates for corresponding lyrical speech (Sebeok & Umiker-Sebeok, 1976) that listeners easily recognize. Instrumental music as a speech surrogate has been noted across Amazonian societies (Moore & Meyer, 2014). The following is a translated excerpt from a traditional song easily recognized by many Tsimane:

> tail swishing tail swishing crocodile, scales scales on the tail
>
> trail in sand, trail in sand, trail in sand, crocodile's tail
>
> ha ha, swimming crocodile, o o, it says angry
>
> there it goes in the water
>
> crawling on the floor, scales scales on the tail
>
> went to its house like a convent

Traditional Tsimane songs provide pedagogical benefits; their lyrics reference important animals, plants, fish, and trees, and their delicate relationships with humans (Antezana, 1983; Huanca, 1999; Riester & Roeckl, 1978). Tsimane often sing personal and melancholy improvisational songs to spouses and neighbors, disclosing candid details of love affairs, sexual exploits, complaints, lamentations, and confessions. Doing so may provide therapeutic benefits and help resolve conflict by bringing interpersonal problems out into the open so that others may calibrate their responses. The following is a translation of an improvised song:

> “then I won't leave you,
>
> together we will live”.
>
> then I won't be with you.
>
> I will then be with another beauty.
>
> I will live with another man then I won't want you.
>
> I won't want you.

[2]“Telling the hunt” has also been described in other foraging societies (e.g., see Biesele, 1993).

I will get myself another.

I will get a good husband.

Across cultures, people are motivated to interpret dreams: a process of attributing important meaning that influences judgments and impacts daily life (Morewedge, Giblin, & Norton, 2014). Among Tsimane, skilled listeners offer personalized interpretations of dreams and suggest possible omens revealed. The interpreted content of dreams can affect a number of decisions, including when to hunt, and when to avoid long trips into the forest. About 22% of adults 15–29 years old interpret dreams but the proportion is higher with age: 70% of oldest adults (60 + years old) interpret dreams (Fig. 1).

1.2. Hypotheses and predictions

We test predictions based on two hypotheses offering distinct views about the timing and circumstances affecting traditional information transmission. The first hypothesis proposes that storytelling is a *common skill* enabled by expertise across all skill domains. The second hypothesis proposes that, due to its high knowledge and low strength requirements, storytelling is a *specialized skill* more cultivated by adults with a comparative advantage in high knowledge skills and a comparative disadvantage in skills requiring substantial strength or agility.

(1) **Age, knowledge, and storytelling**: Of all cognitive abilities, the "crystallized" abilities for vocabulary (providing definitions of words), information (answering general knowledge questions), semantic memory (names and properties of things), and comprehension (explaining why things happen) peak latest in life – during the post-reproductive lifestage (Hartshorne & Germine, 2015). Relying on these cognitive abilities, we expect that story knowledge and storytelling should not show the greater age-related declines observed in skills involving strength and motor dexterity or "fluid" cognitive abilities (Gurven et al., 2017). As a result, those older adults who know and can tell the most traditional stories, are positioned best for the *specialized skill* of storytelling.

P1.1: The number of stories known accumulates with age – even into late adulthood.

P1.2: The number of stories told is positively associated with the number of stories known, adjusting for age.

P1.3: Older adults have a greater propensity to tell known stories.

Alternatively, if storytelling is a *common skill* and informants' learning and telling of stories is predicted by their abilities across all skills, we expect the null for **P1.1–P1.3**: story knowledge and telling will peak in mid-adulthood before declining in later adulthood.

(2) **Costs, benefits, comparative advantage, knowledge and storytelling**: The ability to learn the oral tradition may be constrained for Tsimane who are more market acculturated and more exposed to non-traditional culture. Tsimane most frequently encounter non-traditional media (radio programs, television and movies, prerecorded music, printed news) near the San Borja marketplace. Market

acculturation and formal school education may lead to reduced experience with the natural environment and traditional lifestyles. This loss of experience limits a person's available time and attention for learning traditional stories (Nabhan & St. Antoine, 1993). Tsimane who are frequently exposed to non-Tsimane narratives and music (e.g. from prerecorded videos and music) may be using their limited time and cognitive resources to better learn these, at the expense of learning their oral tradition.

P2.1: More market exposed informants with shorter *market travel distance* and greater *market acculturation* report knowing fewer traditional stories.

Alternatively, more market acculturated storytellers may experience advantages. Market acculturated Tsimane (who tend to be more educated, with better Spanish reading and writing skills) intensely and broadly provision other Tsimane in their networks (Gurven, Jaeggi, von Rueden, Hooper, & Kaplan, 2015). With more developed verbal abilities and larger social networks, market acculturated Tsimane may have more opportunities to develop traditional story knowledge.

P2.2: Informants with greater *market acculturation* report knowing more traditional stories.

Potential costs to telling traditional stories (e.g. social anxiety, poor audience reception, opportunity costs) may lead storytellers to avoid telling the stories they know. However, as a *specialized skill*, storytellers may offset age-related declines in fitness value by telling a greater proportion of the stories they know when at a comparative advantage to do so.

P2.3: Storytellers with comparative disadvantage in production and service domains outside of the oral tradition, but with comparative advantage in the oral tradition, tell more known stories.

(3) **Available audience and storytelling**: As a *common skill*, storytelling will occur among competent individuals who might tell stories to any available audience that could generate benefits (e.g. coalitionary support, deference) in exchange for the entertainment and information they are provided. Village and residential audience availability could therefore incentivize storytelling: marginal benefits may increase with the size of these audiences.

P3.1: Storytellers with larger available village or residential audiences are more likely to tell known stories.

Alternatively, if storytelling entails opportunity costs and storytellers benefit most from a close-kin audience– audience composition may affect the propensity to tell known stories. As a *specialized skill*, we hypothesize that storytelling could be used to benefit inclusive fitness of the transmitter. We expect Tsimane storytelling to be biased towards the storyteller's descendants and kin, rather than indiscriminately towards any grouping of villagers able to listen.

P3.2: Storytellers with larger available residential kin audiences are more likely to tell known stories.

(4) **Nomination of same-sex older kin and non-parental story sources**: If storytelling is a *specialized skill*, informants are likely to have learned their stories from select storytelling specialists. Ceteris paribus, close kin are more reliable as story sources due to shared genetic interests, and older adults may be more reliable due to cumulative knowledge and experience. Tsimane demonstrate a strong sexual division of social space and labor making same sex information transmission more convenient and appropriate for skill development. The friendliness and egalitarian power relations between children and their same-sex non-parental older relatives (e.g. grandparents) are expected to further affect story-source nomination by informants.

P4.1: Targets who are closer in kinship, older than, and the same sex as informants are more likely to be nominated as story sources.

P4.2: Holding kinship, older age, and same-sex constant, targets who are non-parents to informants are more likely to be nominated as story sources.

Alternatively, if storytelling is a *common skill* and informants learn from targets who have high ability across all skill domains, we should expect the null for **P4.1** and **P4.2**:

2. Material and methods

Interviews for this study were carried out by the lead author with assistance of a Tsimane research assistant. Family units were identified from THLHP census information. Using the *Skills Survey* reported by Schniter et al. (2015), participants were interviewed at their homes about their skills (including educational achievement and Spanish reading and writing ability) and the skills of others (i.e., nominating experts for specific skills). In Appendix C we detail the statistical framework that we use to recover ability measures from expert nominations. In calculating ability scores, we use the natural log of mean expertise scores that are calculated by dividing the sum of expertise scores (for every skill in a category or categories) by the total number of sex-appropriate skills in a category (i.e., oral tradition, chores & crafts, food production, reproduction & childcare, social & market) or categories. We consider *oral tradition ability, overall ability* (across all skill categories), and *comparative advantage with oral tradition* (the ratio of oral tradition ability to ability across all other categories), measures explained in Appendix C.

Individuals' residential locations and travel routes were recorded using a handheld GPS unit. *Market travel distance* ($M \pm SD = 56.9 \pm 28.7$ km) was calculated using mapped travel routes between residences and the San Borja marketplace. For our proxy of *market acculturation*, we calculated the principle component of three acculturation measures (Spanish speaking fluency, Spanish reading fluency, level of education achieved) identified from THLHP census information and previously shown to be positively interrelated in large Tsimane samples (e.g. Gurven et al., 2015). The *market acculturation* scores for informants ranged from −1 to 2.9 (0 ± 1).

To measure aspects of available audience size, we used census information to quantify the size of storytellers' potential younger kin audiences in multi-household residential clusters

(*residential younger kin audience size*) and of potential audiences (all ages, kin and non-kin) at the village-wide level (*village audience size*).

Thirteen percent ($N = 54$) of Tsimane participants from the *Skills Survey* in 2006 ($N = 421$, aged 15–86, 51% male) reported knowing at least one traditional story (18% of males, 8% of females). These 54 adults were administered a follow-up *Traditional Stories Survey* querying whether or not they knew each of 120 stories from the Tsimane oral tradition, including 56 fables, 30 realistic or historical stories, 19 stories with felines, 11 Dojity and Micha stories, and 4 stories explaining cosmology (for data, see Schniter, 2017). Appendix B contains an index of titled and categorized stories. We asked story-knowledgeable adults whether they had ever retold the stories they knew. We also asked informants to identify up to five primary sources from whom they learned stories.

Based on the kin relation between informants and the primary story sources identified, we classified information transmission patterns as *vertical, oblique, or horizontal*. Consistent with Cavalli-Sforza and Feldman (1981), we distinguish parent-to-offspring transmission as *vertical*, all other older-to-younger kin transmission as *oblique*, and sibling, cousin and other peer transmission as *horizontal*.

2.1. Statistical analyses

We use negative binomial regression to model the reported number of *stories known*, a set of over-dispersed count data for which the variance ($\sigma^2 = 161.8$) exceeds the mean (M = 3.5, range: 0–112). Given that the number of *stories told* is predicted (and bounded) by the number of *stories known*, we consider predictors of *storytelling* (telling known stories) rather than predictors of number of *stories told*. To evaluate predictors of *storytelling* we use logistic regression analysis.

Logistic regression analysis was also conducted to predict story source nominations using target-informant relationship characteristics where available among possible target-informant dyads ($N = 8424$). Dyads were based on combinations of story knowledgeable informants (N = 54) and the group of possible targets ($N = 157$). To identify possible story source nomination targets, we examined 128 story source nominations by 54 informants, and identified a total of 120 named sources (“targets” in our nomination model). 17 of our informants are among these sources. Our set of possible targets (N = 157) includes all 54 story-knowledgeable informants and all 103 named sources who are not informants. As all informants are among the set of 157 possible targets, 54 of the 8478 informant-target combinations are self-referential and are not included in the set of possible target-informant dyads.

3. Results

Among the 54 informants aged 19–77 (age 46.7 ± 16.5, 70.4% male) knowing traditional stories, an average of 32.3 ± 23.4 stories (26.9% of 120 stories) are reported known. While 99% (119/120) of the traditional stories surveyed are told and several informants reported a repertoire of up to 110 stories (and others told as little as one or no stories) the average informant told 21 stories or 65.6% of the stories they knew (for average by story category

see Appendix B). Twelve percent ($N = 52$) of our Tsimane skills sample said they regularly tell one or more traditional stories.

Most stories (96.7%) contain information relevant to food production or sociality (Table 2). The average story-knowledgeable informant knows only a minor portion of stories of a particular type, or containing particular information content, but tells the majority of stories they know in each of these categories (see Online Supplement for story and category details). We report results for all 120 traditional stories throughout this paper.[3]

3.1. Story knowledge

Using negative binomial regression analysis, we evaluated the separate and combined effects of informants' age, sex, and market measures on reports of stories known for the full dataset of informants including those reporting no knowledge of traditional stories ($n = 421$). There is a significant positive association between number of *stories known* with age (Table 3). According to our model, one decade is associated with an additional 11 stories known. There is no evidence of plateaus or declines in numbers of stories known throughout adulthood (Fig. 2), consistent with **P1.1**. The model considering both informant's older age and female sex indicates that women report knowing 2.9 fewer stories than same-aged men at age 35 and 33 fewer stories at age 65 (Table 3). There is a small but positive, *age × sex* interaction effect indicating that males continue to learn more stories during adulthood at a faster rate than do females (Table 3). We consider whether informants' *market acculturation* and *travel distance* to the market center bear any relation to *stories known*. Both *market acculturation* and *travel distance* to the market center are associated with *stories known*: for each standard deviation an informant is above the mean level of acculturation, males(females) know 0.06(0) more stories, and for each additional 90 km of travel distance that informants live further from the San Borja market center, males(females) know 1(0) additional story (Table 3). While we find a small travel distance effect of male storytellers knowing fewer stories when living closer to the market center, consistent with **P2.1,** we also find a small market acculturation effect: greater Spanish language fluency and educational achievement of male storytellers are associated with knowing more stories –consistent with **P2.2.**

We next evaluated the relationship between the number of stories told and the number of stories known. The amount of stories that story-knowledgeable informants tell increases with the amount of stories they know (Pearson $r = 0.73$, $p < 0.001$). On average, story-knowledgeable men tell 22.6 (±24.6) stories compared to 17.6 (± 16.2) stories told by story-knowledgeable women, which is not a significant difference ($t(44) = -0.69$, $p = 0.421$). The number of stories told is positively associated with age ($r = 0.29$, $p = 0.048$) as seen in Fig. 2 (panel B). In a full negative binomial regression model with age, stories told is positively predicted by stories known ($\beta = 0.15$, $p < 0.001$). These results support **P1.2**, that at any given age, the number of stories told is associated with the number of stories known.

[3]We found the same results for the 116 stories with information relevant to food production or sociality.

3.2. Storytelling

Using logistic regression analysis, we evaluated the effects of informant characteristics (*age, sex, age* × *sex, oral tradition ability, overall ability, comparative advantage with oral tradition*) and informant's available audiences (*residential younger kin audience size* and *village audience size*) on *storytelling* (i.e., *stories told* per *stories known*) for our 54 story-knowledgeable informants. **P1.3** is supported by results of models 3, 4 and 5 in Table 4, suggesting that among adults considered expert in the oral tradition, with a comparative advantage in the oral tradition, and with smaller residential kin audiences, older adults are more likely to tell known stories. We also find that storytelling is more likely among men ($p = 0.005$) (Table 4). A small age × sex interaction effect ($p < 0.001$) reveals that this sex difference in storytelling decreases slightly at older ages (Table 4: Model 1). All subsequent models include age, sex, and an age x sex interaction, but individually consider three expertise-related variables. We see no effect of adding *overall ability* ($p = 0.872$) on storytelling (Table 4: Model 2). We find that having more *oral tradition ability* ($p = 0.033$) is associated with more storytelling (Table 4: Model 3). Finally, we find that having greater *comparative advantage in the oral tradition* ($p = 0.021$) is associated with more storytelling (Table 4: Model 4), consistent with **P2.3**. In general, storytellers are most likely to be nominated for expertise in the oral tradition, for which they have higher ability scores (M = 0.42 ± 0.22), than in all other skills (M = 0.37 ± 0.02); this pattern is reversed among non-storytellers who have lower ability with oral tradition skills (M = −0.22 ± 0.25) than they do with all other skills (M = 0.13 ± 0.02).

The average residential cluster in our sample was composed of 5.8 ± 5.1 households with an average of 6.4 individuals per household. A minority of our informants ($N = 5$) lived outside of residential clusters: either in single household residences ($N = 4$), or alone ($N = 1$). While most (49/54) informants had an available residential audience of no more than 44 people, 5 informants had available residential audiences larger than 130 people. 87.4 ± 0.1 of an informant's residential audience consists of younger kin. Village sizes range from 66 to 325 people, with an average potential audience of 204 ± 106 people.

When evaluating the effects of audience characteristics (*residential younger kin audience size*, *village audience size*) along with informant characteristics (*age, sex, age* × *sex, comparative advantage in oral tradition*), we find no significant effects of village audience size ($p = 0.267$), but a significant effect of smaller residential kin audiences ($p = 0.005$) on *storytelling*. These results and the direction of the residential kin audience effect on storytelling are not supportive of **P3.1** and **P3.2**, that larger available audience sizes will increase storytelling (see Table 4).

3.3. Story sources

Informants made most story source nominations of kin (114/128 or 89%), especially of older kin (108/128). Of all story source nominations, we classify 30 (23%) as *vertical* (parents), 78 (61%) as *oblique* (older kin including grandparents, parents, aunts/uncles, father-in-law/mother-in-law), and 20 (16%) as *horizontal* transmitters (i.e., members of peer-groups such as siblings, cousins, nephews/nieces, brother-inlaws/sister-in-laws, and non-kin acquaintances). Table 5 shows how story source nominations depend on the potential

story source's *consanguineal* and *affinal relatedness* (i.e., blood relatedness to informant or informant's spouse, respectively). In the region of the matrix where both the *consanguineal* and *affinal relatedness* coefficients are less than one-eighth, the nomination probability is 1%: outside of that region where coefficients of relatedness are higher, the expert nomination probability is an order of magnitude higher, at 25%. There is a high probability (66%) of nomination among *consanguineal kin* of intermediate relatedness (where r = 0.125 to 0.25 for great-grandparents, grandparents, grandchildren, aunts, and uncles), much higher than the probability (12%) for close consanguineal kin (where r = 0.5 for parents, siblings, and offspring). Note, however, that no nominations are recorded for grandchildren or children despite their close kinship and greater representation in local kin groups.

Consistent with the results reported in Table 5, *kinship* plays an important role in nomination probability: for each additional tenth of a degree of closer relatedness (either to informant or to informant's spouse, whichever is higher), targets are 92 times more likely to be nominated as story sources (Table 6). Older *vertical & oblique* targets are 8.5 times more likely to be nominated as story sources than peer-based *horizontal* targets (Table 6). *Same-sex* targets are 51% more likely to be nominated as story sources than are opposite-sex targets (Table 6). *Close-kin, vertical & oblique*, and *same-sex* target-informant characteristics remain jointly significant in a model that considers all three simultaneously (Table 6). These results support **P4.1** that targets who are the same sex as, closer in kinship to, and older than informants are more likely to be nominated as story sources.

While older *vertical & oblique* targets are significantly more likely to be nominated than *horizontal* peers, being a *parent* (i.e., a “vertical” target) is not a significant predictor of getting *nominated* (Table 6). Indeed, grandparents are the most nominated category of kin, accounting for 38% of nominations, followed by parents (30%), aunts/uncles (14%), in-laws (3%), cousins (2%), nephews/nieces (1%), and siblings (1%). Our full model shows that nominations are preferably of targets who are same-sex, older, and closer consanguineal or affinal kin but not parents (Table 6), consistent with **P4.2**.

4. Discussion

Storytelling has long served as an important means of transmitting cumulative culture and traditional ecological knowledge (TEK), especially in the absence of books and other means of information storage. While TEK and culture transmission studies frequently recognize that older adults play an important role in information transmission, little is known about the development and timing of storytelling abilities, whom young adults primarily learn stories from, and which elders are more likely to be storytellers. A novel contribution of this study is that it provides precise quantification of the age effect on story knowledge and storytelling, and precise quantification of the transmission patterns responsible for story learning.

Most of the stories (97%) indexed in our *Traditional Stories Survey* contain information relevant to Tsimane foraging or sociality. Reports from across our sample of story-knowledgeable informants indicate that Tsimane oral tradition is alive and well: all but one of 120 stories have been retold by the current group of storytellers (see Appendix B Table

C). The information Tsimane transmit via storytelling could not reasonably be acquired by individuals on their own, yet sources of this information are relatively rare: only 13% of the Tsimane *Skills Survey* sample ($N = 451$) reported knowing traditional stories, compared to the 99% who reported using a machete (Schniter et al., 2015). Furthermore, as most storytellers know only a quarter of the inventory of traditional stories, and tell a little over half of what they know, different storytellers know different material – allowing room for repertoire specialization among storytellers.

Traditional stories that we studied need not be restricted to a single gender of storytellers. Though a greater proportion of the traditional stories are told by men, we cannot say that men are more likely to tell most of these stories due to small sample sizes of men and women knowing particular stories. That 26.7% (32/120) of stories are told by men but not women, and no stories are told only by women (see Appendix B Table C) may be a consequence of the male-only set of principal informants who helped construct the *Traditional Stories Survey*. Future studies might benefit from female informants contributing additional stories to the *Traditional Stories Survey*.

The late age of storytelling specialization among a minority of older adults that we note is quite different than the pattern of skill generalization otherwise observed, where most adults possess most skills. We can interpret storytelling over the lifespan of men and women as part of their life history strategies. The greater story knowledge among men of all ages may reflect a strategy where older men specialize in storytelling to buffer the greater and more rapid declines in food production (from peak production levels) that they experience compared to women (Hooper, Gurven, Winking, & Kaplan, 2015). Women also demonstrate a post-reproductive shift towards greater storytelling: After the sixth decade of life they may up-regulate storytelling to buffer the productive losses associated with strength and skeletal mass declines (Stieglitz et al., 2015) that impact women's food production and processing abilities. These age effects are more consistent with storytelling being a specialized rather than common skill. We study age because it is a reliable proxy for strength. Future studies of oral tradition could benefit from more direct measures of strength and agility.

We have also considered evidence in support of different explanations for why storytelling might be a service niche for only a minority of adults. We find no support for the hypothesis that storytelling is a common skill enabled by overall ability across all skill domains and larger available audience size. Instead we find evidence supporting the notion that storytelling is a specialized skill that develops to buffer senescence-related declines in high-strength, high-agility caloric provisioning abilities: storytelling is closely associated with story knowledge, oral tradition ability, and a comparative disadvantage in all other skill domains.

The greater knowledge of traditional stories we report with age may be explained by elders having had more opportunity to learn stories, and it might also be explained by a trend towards less story learning among younger generations. Schniter et al. (2015) estimated the percent change in the skill acquisition hazard rate per year between 1960 and 1993. From those analyses we know that younger cohorts of adults (especially men aged 21–29) sampled in the *Skills Survey* acquired knowledge of traditional stories at an 80% lower rate (Z =

−5.91 $p < 0.00001$) than a same aged generation 33 years earlier (a difference not seen for very common skills like using a machete (Z = −0.38 $p = 0.703$)). This effect may be driven by young men in that age range who are more involved in wage labor than older men, and women at any age (Gurven, Winking, Kaplan, von Rueden, & McAllister, 2009). If the greater story knowledge we report among older men is due in part to younger men's greater acculturation to and involvement with the local non-traditional market society we would expect market proximity and acculturation to predict story knowledge for our male sample, yet we find poor support for these explanations: while living closer to San Borja was associated with slightly less story knowledge, greater schooling and Spanish fluency were associated with more story knowledge – not less. This greater story knowledge may be a consequence of greater intelligence, if the two are related. We remind readers that these acculturation and proximity effects are only proxies of market integration, are found with males but not females, and are very small. Never the less, our results are robust to presence of these effects that are controlled for in relevant analyses. Future studies of Tsimane oral tradition could benefit from more direct measures of market integration, such as income and wealth.

Our analyses reveal that traditional stories are transmitted across generations from older, more knowledgeable adults, to younger less knowledgeable recipients. Nominations for story sources indicate that traditional stories are learned mostly from same-sex older relatives (84%), and especially from grandparents. We find similar transmission patterns when evaluating older storytellers apart from younger adults aged 20–29, suggesting this is not confounded by a cohort effect. This evidence supports a two-sex, three-generational model of oblique traditional information transmission among Tsimane. This pattern of traditional information transmission is consistent with previous reports of same-sex Tsimane skill transmission (Reyes-García et al., 2009; Schniter, 2009) and with de Laguna's (1997) report of Yakutat Tlingit hunter-gatherers learning traditional stories from grandparents more than from parents. The pattern of traditional information transmission we report in this paper is inconsistent with reports of parent to offspring transmission as the most common vector for learning traditional information: such as with folktale transmission in Arctic hunter-gatherer societies (Ross & Atkinson, 2016) or with subsistence skills among foragers and peasants (e.g. Hewlett & Cavalli-Sforza, 1986; Ohmagari & Berkes, 1997; Ruddle & Chesterfield, 1977; Schniter, 2009). Below we discuss reasons for greater storytelling at later ages, and for this three-generational oblique transmission pattern (from grandparent to grandchild) for learning traditional stories.

Our findings about the development of skills in the oral tradition and patterns of *oblique* information transmission across alternate generations may help extend our understanding of the evolved human life history by illustrating how age-related changes in embodied capital are associated with late-life development of information transmission services that can impact grandchildren. As humans cease reproducing and advance well into their grandparental years, mortality risks continue to increase while their expected fitness contributions (e.g. from food procurement) diminish – making continued investment in various forms of maintenance and repair increasingly less worthwhile. While this perspective helps explain the loss of strength and somatic resources with age, the slow rates of cognitive aging observed in humans and their potential additive role in promoting

a long post-reproductive lifespan remains a puzzle worthy of study. Schwarz et al. (2016) provide genetic evidence supporting selection in humans against post-reproductive cognitive decline and Gurven et al. (2017) demonstrate that semantic fluency (generating lists of animal and fish names) improves or remains well developed throughout adulthood among both schooled and non-schooled Tsimane, consistent with a late life niche emphasizing information transmission. In fact, this effect may extend to industrialized populations: A large survey of labor market productivity across adult ages finds that for jobs where problem solving, learning and speed are needed, productivity decreases from around 50 years of age, while in jobs where experience and verbal abilities are most important, older workers' maintain a relatively high productivity level (Skirbekk, 2004). By considering the benefits likely derived from oral transmission of accumulated knowledge, whether for forager-horticulturalist economies or for employees in modern labor markets, we may better explain the human curiosity of post-reproductive cognitive maintenance.

In small-scale subsistence societies, some older adults serve as the “libraries” of accumulated cultural and practical knowledge, suggesting that human evolution has selected for post-reproductive cognitive skill maintenance. Through storytelling and musical performance, important information can be relayed from older to younger kin regarding socialization and education, and for audiences of all ages, storytellers can provide entertainment and opportunity for social activity that could help reinforce social ties and promote social cohesion (Boyd, 2009). While previous research has demonstrated the role that Tsimane adults play in politics and conflict resolution (e.g. Gurven & Kaplan, 2008; Gurven, Stieglitz, Hooper, Gomes, & Kaplan, 2012; von Rueden, Gurven, Kaplan, & Stieglitz, 2014), we now have evidence that older adults play a role in educating younger kin via oral tradition performance. Perhaps in facilitating these fitness enhancing benefits, oral traditions have also helped extend our lifespan.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability

The data are available at Mendeley Data (Schniter, 2017) and will be made available upon request.

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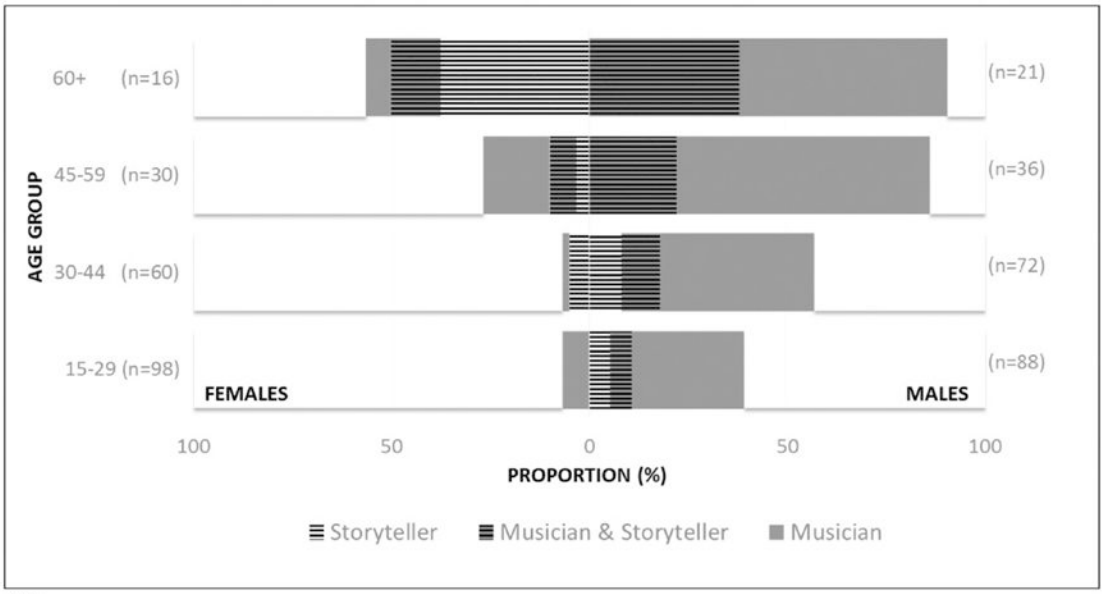
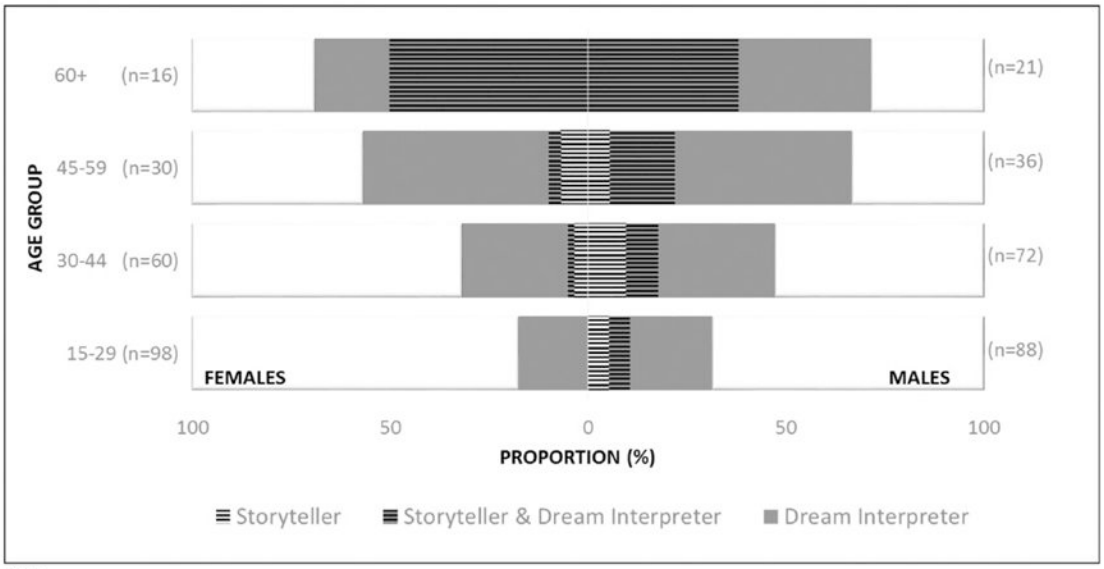


(A)



(B)

Fig. 1.

Proportion of adults in sex-specific age groups reporting to be storytellers and musicians (panel A; N = 421) and proportion of adults in sex-specific age groups reporting to be storytellers and dream interpreters (panel B; N = 421). Data adapted from Schniter et al. (2015).

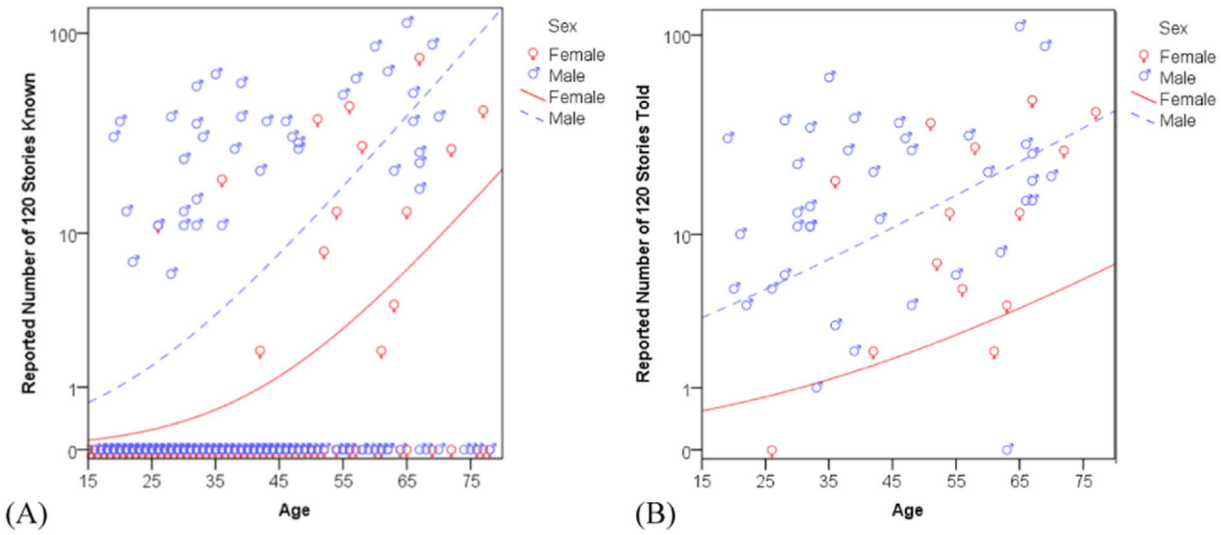


Fig. 2.

Number of *stories known* among *Skills Survey* informants (panel A; N = 421) and number of *stories told* among story-knowledgeable informants (panel B; N = 54).

Table 1

Ages of self-reported acquisition and nominated expertise across traditional Tsimane skill sets.

Skill category	Acquisition		Expertise	
	Female	Male	Female	Male
Child care	17.4 (18.3)	20.0 (20.6)	45–57	38–86
Food production (hunting, fishing, gardening)	15.0 (15.7)	16.4 (17.2)	36–77	63–72
Chores and craft production	15.8 (16.6)	18.3 (19.2)	59–77	55–86
Oral tradition (music and stories)	20.0 (21.0)	22.5 (25.5)	65–77	66–86

Note: “Acquisition” refers to the reported age when 90% of informants could self-sufficiently perform the skill without necessary delegation, supervision, or guidance. In parentheses we provide the 95% Upper Confidence Interval for these “Acquisition” point estimates. For “Expertise” we provide ages at which targets are most recognized as experts according to consensus nomination likelihood estimates. Adapted from Schniter et al. (2015).

Table 2

Average story knowledge and average storytelling by story category.

	Total stories in category	Stories known (SD)	Percent of total stories known	Stories Told (SD)	Percent of known stories told
All stories					
	120	32.3 (23.4)	26.9	21.1 (20.9)	65.6
Mutually exclusive story categories (type)					
Fables	56	17.3 (12.0)	30.9	11.6 (11.1)	67.1
Realistic or historical stories	30	4.8 (5.5)	15.9	2.7 (5.1)	56.3
Stories with felines	19	6.5 (4.3)	34.3	4.5 (4.0)	69.2
Stories with Dojity and Micha	11	2.9 (2.7)	25.9	1.6 (2.3)	55.2
Cosmology stories	4	0.5 (1.1)	12.0	0.4 (1.0)	80.0
Non-exclusive story categories (information content)					
Stories with information relevant to food production	89	26.6 (18.3)	29.9	17.6 (16.3)	66.2
Stories with information relevant to sociality	77	21.0 (15.1)	27.2	13.7 (13.9)	65.2
Stories with either information relevant to food production or to sociality	116	31.9 (22.9)	27.5	20.8 (20.4)	65.2

Note: For an index of 120 traditional stories, story categorizations, and category explanations see Appendix B.

Table 3

Negative binomial regression of *stories known* on informant characteristics.

Dependent variable	**Stories known**	**Stories known**	**Stories known**	**Stories known**
Model	**(1)**	**(2)**	**(3)**	**(4)**
Age	0.070*** (0.0043) [267.875]	0.081*** (0.0048) [288.421]	0.129*** (0.0101) [160.998]	0.123*** (0.0101) [148.093]
Sex (female)		−1.823*** (0.1465) [154.856]	−4.916*** (0.5364) [84.004]	−4.359*** (0.5354) [66.278]
Age × Sex			−0.072*** (0.0115) [38.888]	−0.062*** (0.0115) [29.451]
Market acculturation				0.303*** (0.0810) [14.044]
Market travel distance				0.016*** (0.0029) [29.372]
Constant	−1.740*** (0.1756) [98.182]	−1.593*** (0.1864) [146.964]	−0.703*** (0.2223) [138.947]	−1.816*** (0.3019) [164.618]
Likelihood Ratio Chi-Square	355.594***	526.341***	572.674***	604.661***
Observations	421	421	421	421

Standard errors in parenthesis. Wald Chi-square values in brackets.

*** Significant at 1%.

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Table 4

Negative binomial regression of *storytelling* on informant characteristics and available audience characteristics.

Dependent variable	**Storytelling**	**Storytelling**	**Storytelling**	**Storytelling**	**Storytelling**
Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Age	0.039 (0.0104) [13.940]	0.039 (0.0104) [13.705]	0.027 ** (0.0119) [4.990]	0.025 ** (0.0122) [4.071]	0.030 ** (0.0124) [5.916]
Female	−1.777 *** (0.6378) [7.759]	−1.779 *** (0.6386) [7.763]	−1.121 (0.7148) [2.461]	−0.986 (0.7308) [1.819]	−1.162 (0.7360) [2.491]
Age × Female	−0.041 *** (0.0109) [14.066]	−0.041 *** (0.0110) [13.971]	−0.035 *** (0.0115) [8.974]	−0.033 *** (0. 0117) [7.878]	−0.034 *** (0.0118) [8.045]
Overall ability		0.482 (2.9951) [0.026]			
Oral tradition ability (OT)			0.779 ** (0.3658) [4.531]		
Comparative advantage in OT				0.931 ** (0.4022) [5.364]	0.399 (0.4384) [0.827]
Residential younger kin audience size					−0.006 *** (0.0023) [7.921]
Village audience size					−0.001 (0.0006) [1.233]
Constant	0.628 *** (0.1808) [0.667]	0.624 *** (0.1820) [0.685]	0.788 *** (0.1958) [0.329]	0.826 *** (0.2002) [0.652]	0.958 *** (0.2107) [0.807]
Likelihood Ratio Chi-Square	35.350 ***	35.276 ***	39.812 ***	40.656 ***	51.370 ***
Observations	54	54	54	54	54

Standard errors in parenthesis.

Wald Chi-square values in brackets.

** Significant at 5%.

*** Significant at 1%.

Table 5

Nomination probability (and number of observed nominations/possible targets), given kinship of potential story source target to informant.

		***Consanguineal relatedness*: kinship of target to informant**					**Overall**
		0.500 to 0.999	**0.250 to 0.499**	**0.125 to 0.249**	**0.001 to 0.124**	**0**	
Affinal relatedness: kinship of target to informant's spouse	1	(0/0)	(0/0)	(0/0)	(0/0)	0 (0/14)	0 (0/14)
	0.500 to 0.999	0 (0/13)	0.5 (1/2)	(0/0)	(0/0)	0.071 (5/70)	0.071 (6/85)
	0.250 to 0.499	(0/0)	0.2 (1/5)	1 (1/1)	(0/0)	0.071 (3/42)	0.104 (5/48)
	0.125 to 0.249	0 (0/2)	(0/0)	0 (0/1)	(0/0)	0 (0/19)	0 (0/22)
	0.001 to 0.124	(0/0)	(0/0)	(0/0)	(0/0)	0 (0/6)	0 (0/6)
	0	0.463 (44/95)	0.595 (47/79)	0.667 (18/27)	(0/0)	0.022 (122/5441)	0 (156/5642)
	Overall	0.4 (44/110)	0.570 (49/86)	0.655 (19/29)	(0/0)	0.008 (44/5592)	5817 possible targets[a]

Note. Consanguineal relatedness is expressed with the coefficient of relationship *r*, as defined by Wright (1922). We also use an affinal coefficient of relationship, based on consanguineal relatedness (r) calculated from the spouse's perspective.

[a]Kinship relationship information is missing for 31% of all 8424 possible target-informant dyads.

Table 6

Regression of *story source nomination* on target-informant relationship characteristics.

Dependent variable	**Nominated**	**Nominated**	**Nominated**	**Nominated**	**Nominated**	**Nominated**
Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Vertical & oblique †	1.793*** (0.263)			2.149*** (0.300)		2.103*** (0.337)
Same-sex		0.413** (0.189)		0.892*** (0.238)		1.130*** (0.272)
Kinship †			6.827*** (0.402)	7.661*** (0.476)		5.658*** (0.486)
Parent					25.682 (6436.026)	22.900 (6019.426)
Constant	−4.800*** (0.244)	−3.986*** (0.105)	−4.372*** (0.121)	−5.425*** (0.303)	−5.578*** (0.209)	−5.321*** (0.328)
Nagelkerke's *R*-squared	0.066	0.004	0.244	0.363	0.261	0.421
Observations	5817	8424	5817	5817	8424	5817

Standard errors in parenthesis.

** Significant at 5%.

*** Significant at 1%.

† Dependent variable information is missing for 31% of all 8424 possible target-informant dyads.