The forager oral tradition and the evolution of prolonged juvenility

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The foraging niche is characterized by the exploitation of nutrient-rich resources using complex extraction techniques that take a long time to acquire. This costly period of development is supported by intensive parental investment. Although human life history theory tends to characterize this investment in terms of food and care, ethnographic research on foraging skill transmission suggests that the flow of resources from old-to-young also includes knowledge. Given the adaptive value of information, parents may have been under selection pressure to invest knowledge – e.g., warnings, advice – in children: proactive provisioning of reliable information would have increased offspring survival rates and, hence, parental fitness. One way that foragers acquire subsistence knowledge is through symbolic communication, including narrative. Tellingly, oral traditions are characterized by an old-to-young transmission pattern, which suggests that, in forager groups, storytelling might be an important means by which adults transfer knowledge to juveniles. In particular, by providing juveniles with vicarious experience, storytelling may expand episodic memory, which is believed to be integral to the generation of possible future scenarios (i.e., planning). In support of this hypothesis, this essay reviews evidence that: mastery of foraging knowledge and skill sets takes a long time to acquire; foraging knowledge is transmitted from parent to child; the human mind contains adaptations specific to social learning; full assembly of learning mechanisms is not complete in early childhood; and forager oral traditions contain a wide range of information integral to occupation of the foraging niche. It concludes with suggestions for tests of the proposed hypothesis.
Keywords: embodied capital, foraging niche, information exchange, mental time travel, oral tradition, prolonged juvenility, social learning, storytelling

"The cognitive ability to represent situations removed from the immediate sensory field is... basic to the social hunting and gathering adaptation. In particular, the capacity to recreate situations for others and to convey to them what has been found to be of interest and of value has been of great adaptive worth" (Biesele, 1993, p. 42).

Introduction

Occupation of the foraging niche requires considerable stamina, strength, coordination, skill, and – significantly – knowledge, which require a long time to acquire (Kaplan et al., 2000, 2007; Gurven et al., 2006). This costly period of development is supported by intensive parental (Lancaster and Lancaster, 1983) and alloparental (Hrdy, 2005, 2009) investment. Although human life history theory commonly characterizes this investment in terms of food resources and care (Lancaster and Lancaster, 1983; Kaplan et al., 2000, 2007), ethnographic research on the transmission of foraging skills suggests that the flow of resources from old-to-young includes information as well. Although certain skills are acquired and/or refined through play (Bruner et al., 1976; Boulton and Smith, 1992; Steen and Owens, 2001; Bock, 2002; Pellegrini and Bjorkland, 2004; Göncü and Gaskins, 2007; Pellegrini, 2011), ethnographic evidence suggests that children acquire much of their knowledge from their parents (Hewlett and Cavalli-Sforza, 1986; Ohmagari and Berkes, 1997; Shennan and Steele, 1999). This research is paralleled by extensive evidence that cognitive systems dedicated to social learning begin emerging in early infancy (for a review, see Carey, 2009) and that social learning is more highly developed in humans than in any other species (Byrne, 1995; Tomasello et al., 2005). Although an incipient form of this strategy – obtaining access to food resources by exploiting the expertise of conspecifics – is seen in some non-human primates (Stammbach, 1988; Russon, 1997), humans are unmatched in their highly elaborated ability to access the expertise of conspecifics in order to predict and manipulate both the physical and social environment.

Intergenerational information transfer raises the question: in what format(s) is this information transmitted? Humans are distinguished by two highly developed social learning complexes: transmission of physical skills (e.g., knapping stone, making fire) via demonstration and imitation, and transmission of factual knowledge via language (Gibson, 1999). Our highly elaborated ability to share knowledge gives us access to a much greater range of resources than our ape cousins, and enables us to surmount hazardous terrain and vast distances in pursuit of them (Gibson, 1999). Information sharing also "reduces uncertainty and increases efficiency by reducing search costs in hunting" (Hames, 1990, p. 93; see also Heffley, 1981). Specifically, information sharing increases foragers' "sample size of resource distributions and characteristics" and provides "information on prey and patches that the foragers have never exploited" by allowing access to information that "covers long time spans and the experiences of hundreds of individuals" as well as "[e]xtremely rare events unlikely ever to be experienced by a single forager" (Kaplan and Hill, 1992, p. 196). One way that foragers share information is by "telling the hunt" (Blurton Jones and Konner, 1976) – that is, by recounting and listening to others recount their hunting experiences. Among the Ache, for example, "each man usually reports to the others in considerable detail concerning every game item that he encountered that day, and the outcome of the encounter" (Kaplan and Hill, 1992, p. 196; see also Leacock, 1954, p. 14; Laugh-

lin, 1968, p. 308; Nelson, 1969, p. 374; Biesele, 1978, p. 940; Ridington, 1988, p. 47). Although hunting stories are ostensibly exchanged among adults, children certainly overhear them. As Kaplan and Hill (1992) note, an important source of foraging information is older individuals, and most Ache "children have detailed knowledge of resource characteristics and capture techniques before ever foraging themselves" (196). Although genetic relationships between the storyteller and audience members are rarely specified, storytelling in small-scale societies appears to be characterized by a vertical transmission pattern, with elders telling stories to an audience of adults and children (Lowie, 1918; Opler, 1940; McIlwraith, 1948; Jacobs and Jacobs, 1959; Biesele, 1976; Tonkinson, 1978; Ridington, 1988; Sobel and Bettles, 2000). Occasionally, a general pattern of story transmission is identified: for example, in Jicarilla culture, "Those who 'give' the stories to the children stand usually in a grandparental relationship to them" (Opler, 1938, p. xii). Although these observations are anecdotal, a general pattern of old-to-young transmission in an extended family setting can be discerned, which is in alignment with the proposal that parents and alloparents invest knowledge as well as food and care in offspring.

The costs of acquiring information at first hand can be considerable (Kaplan and Hill, 1992), and investment of information in offspring is but one way of defraying these costs. Information may be shared with collateral kin, thereby enhancing the donor's inclusive fitness (Scalise Sugiyama, 2005; see also Sibly, 1999). Information may be also be bartered in social exchanges: recipients might be motivated to reciprocate in the future, saving the donor future information acquisition costs (Kaplan and Hill, 1992; Scalise Sugiyama, 2005). Ya¸nomamö peccary hunting illustrates this point:

> If a hunter encounters a herd, he never pursues it alone. Instead, he returns to the village, notifies all hunters of the herd's location and general direction of movement, and a group hunt is immediately organized. If a lone hunter returned with a white-lipped peccary he would be treated very sternly by the other hunters in the village because he would have driven the herd off and prevented other hunters from sharing in this superabundant resource. Hunters are required to forego their short-term success and share such information. This reduces search costs for all hunters, thus enhancing everyone's hunting efficiency. Over the long-term, the efficiency of the hunter who provides the information is enhanced because he is assured that if someone else encounters a herd he will be notified. (Hames, 1990, p. 93)

Gossip networks are another example of reciprocal information sharing: the price of inclusion is willingness to share gossip with fellow members (Bott, 1971; Capp, 2003). The use of gossip to manage one's own reputation and manipulate the reputations of others (Emler, 2001) illustrates another potential benefit of information sharing: influencing the beliefs and behavior of conspecifics in ways that serve the transmitter's

interests (Scalise Sugiyama, 1996). Finally, visiting other groups for the purpose of acquiring information may provide access to potential mates (Steward, 1938; Kaplan and Hill, 1992; MacDonald and Hewlett, 1999). The proposition that parents invest knowledge in offspring is presented not as an alternative but as a complement to these hypotheses. The claim is not that humans *only* share information with offspring but that, given the value of information and the potentially high cost of acquiring it at first hand, one would expect parental investment to include knowledge as well as food and protection, and that storytelling is an important means of parent-to-offspring knowledge transfer.

This argument assumes that storytelling is an ancient part of *H. sapiens* life. For the same reason that the finely crafted parietal and portable art of Upper Paleolithic Europe is not evidence of a sudden change in human cognitive capacities (McBrearty and Brooks, 2000; Sterelny, 2011), narrative is unlikely to be a recent development. The earliest hard evidence of non-verbal symbolic behavior (shell beads and engraved ochre artifacts found in Blombos Cave, South Africa) dates to 75 kya (Henshilwood et al., 2002; d'Errico et al., 2005), but several lines of evidence indicate that the capacities requisite to these behaviors were in place approximately 300 kya (McBrearty and Brooks, 2000). Similarly, storytelling is dependent on cognitive capacities – e.g., shared attention, theory of mind, episodic memory – that evolved prior to the *H. sapiens* diaspora. Consider the inherent verbal nature of story transmission: because non-verbal media are highly inefficient and imprecise narrative devices (Scalise Sugiyama, 2005), storytelling requires language, which almost certainly evolved before our species migrated out of Africa 100 kya (Falk, 1984; Pinker, 1994; Dunbar, 1996; Holloway, 1996; Locke and Bogin, 2006). Thus, it is likely that human foragers living tens of thousands of years ago were as capable of telling stories as modern foragers. The tales of our ancestors are lost to us, but the oral traditions of historically documented foraging peoples offer a window on our storied past. Although these peoples are not facsimiles of ancestral humans, their lifeway is similar in that they depend largely on foraging for their subsistence, live in small natural-fertility populations, and lack telecommunication, motorized transport, and western medicine (Marlowe, 2005). The thematic similarities between modern forager oral traditions indicate that we would see a similar overlap in content between modern and ancient forager oral traditions.

This paper reviews several lines of evidence in support of the hypothesis that parental investment includes knowledge and that, in forager societies, storytelling is an important means of parent-to-offspring knowledge transfer. Part 2 reviews evidence that acquisition of foraging knowledge takes many years and that this knowledge is transmitted primarily from parent to child. Part 3 reviews evidence that the human mind contains adaptations specific to social learning, and discusses the developmental trajectory of these structures in relation to prolonged juvenility. Part 4 reviews cross-cultural patterns in forager folklore content vis-à-vis key information demands of the foraging niche, and Part 5 suggests possible tests of the proposed hypothesis.

What do forager children need to learn, and how long does it take to learn it?

Humans are characterized by a long lifespan, large brain relative to body size, and long period of juvenile dependency. The evolution of these traits is the subject of vigorous debate, centered on the question of whether learning is a consequence or a cause of prolonged juvenility (Bock and Sellen, 2002; Hrdy, 2005; Konner, 2010). The former view sees prolonged juvenility as the by-product of selection for larger body size: the benefits of larger body size outweigh the costs of the longer growing period they require (Charnov, 1993; Charnov and Berrigan, 1993). A complementary view, the *grandmother hypothesis*, posits that the evolution of longevity was driven by the provisioning of descendants by post-reproductive women (Hawkes et al., 1989, 1997, 1998; O'Connell et al., 1999). The latter view, formulated by Kaplan and colleagues as the *embodied capital hypothesis*, posits that our long lifespan and large brain co-evolved through the exploitation of nutrient-dense resources using complex extraction techniques, the acquisition of which requires a long growth and learning period supported by intensive parental investment (Lancaster and Lancaster, 1983; Bogin, 1997, 1999; Kaplan et al., 2000, 2007). On this view, the costs of investment in growth and development early in the lifespan are offset by the benefits they yield later in the lifespan. In functional terms, embodied capital includes a range of physical and mental attributes, including strength, speed, stamina, immune function, skill, and knowledge. A related argument, the *social intelligence hypothesis*, posits that encephalization was driven by the demands of predicting and manipulating the behavior of conspecifics, necessitating an extended juvenile period for the development of complex social skills and the cognitive capacities that scaffold them (Byrne and Whiten, 1988; Dunbar, 1992, 1996, 2007; Whiten and Byrne, 1997; Flinn et al., 2005). The chief bone of contention between the latter two hypotheses is whether the selection pressures driving encephalization were social or ecological. However, this argument dissipates in light of the role that sharing and cooperation play in hunter-gatherer life (Reader and Laland, 2002; Kaplan et al., 2007; MacDonald, 2007a,b). Humans are social foragers: many of the resource-extraction and foraging-risk-management strategies deployed by foragers rely heavily on intraspecific cooperation (e.g., Tonkinson, 1978; Wiessner, 1982; Berkes et al., 1994), including social learning (Buckley and Steele, 2002; MacDonald, 2007a,b). Cooperative hunting and/or fishing, for example, are practiced across a wide range of cultures (Downs, 1966; Nelson, 1969; Lee, 1979; Hill and Hawkes, 1983; Yost and Kelley, 1983; Hewlett, 1991; Chagnon, 1997; Sugiyama and Chacon, 2000; Brody, 2002), and successful implementation of such strategies can depend on information sharing (e.g., Heffley, 1981; Hames, 1990). Thus, the exploitation of difficult-to-acquire resources – and concomitant tasks such as social exchange, mate acquisition, and child care – require complex manipulations of both the physical and social environment (Locke and Bogin, 2006).

Although different researchers emphasize different areas of growth, there is widespread agreement that successful occupation of the foraging niche requires a high degree of strength, coordination, skill, and/or knowledge; that these attributes require a significant period of time to acquire; and that this costly period of development is supported by intensive parental – and, some argue, alloparental (Hawkes et al., 1997, 1998; Hrdy, 1999, 2005, 2009) – investment. This investment is often characterized in terms of food resources and care (e.g., Lancaster and Lancaster, 1983; Kaplan et al., 2000, 2007). However, both theory and evidence suggest that information transfer is an important component of parental investment. All else equal, individuals who effectively communicated accurate information to close kin would have increased the representation of their genes in subsequent generations. The potential fitness payoffs of sharing information with immature offspring would have been especially large because, due to their small size and inexperience, juveniles are more vulnerable to environmental hazards. For example, "even though a 4-year-old Shuar child might not be able to fend off an attacking anaconda in a direct encounter, knowledge that anacondas tend to hunt near riverbanks could have major fitness benefits for the child" (Barrett, 2005, p. 442). Proactive provisioning of reliable information would have increased offspring survival rates and, hence, parental fitness (Fitch, 2004). As Locke and Bogin (2006) note, "Even a small amount of vocal–verbal behavior would have facilitated warnings and instruction" (274), a claim supported by evidence that the mind contains mechanisms specialized for reasoning about precautions (Fiddick et al., 2000). As language increased in complexity, it exponentially increased the information sharing capacities of humans; however, it also added a new set of selection pressures. By providing an additional means of acquiring economic and social knowledge, language imposed a new learning requirement on ancestral humans: mastery of "skills associated with the social, pragmatic, and performative uses of language" – not only for the purposes of warning and instruction, but also for "deceiving, mollifying, negotiating, and persuading" (Locke and Bogin, 2006, pp. 264–265). In oral cultures, these ends are achieved through the use of such forms as gossip, public speaking, and – significantly – narrative (Scalise Sugiyama, 1996; Locke and Bogin, 2006).

Ethnographic research on the transmission of foraging skills supports the hypothesis that that the flow of resources from parents to children includes information. In a now classic study, Hewlett and Cavalli-Sforza (1986) asked 72 Aka adults, adolescents, and children whether they had each of 50 daily life skills (e.g., shelter construction, net hunting, food gathering, food preparation, infant care, sharing). For each skill, informants were asked if there were any person(s) who had shown them how to perform that skill. Of the 40 adults in the sample, for all skills lumped together, the proportion of individuals who reported being self-taught was 0.9%. Significantly, parents were the primary teachers: for all traits combined, 80.7% of adults reported learning from a parent. Percentages were even higher for key foraging skills: food gathering (89.3%); net hunting (84.5%); sharing (83.9%); infant care (85.6%). A similar study of indigenous knowledge and bush skills asked James Bay Cree women in the villages of Moose Fac-

tory and Peawanuck whether they had a given skill, who their major teacher was, and how old they were when they learned the skill. Parents were by far the most frequent source of knowledge: 61% of Moose Factory participants and 72% of Peawanuck participants named one or both parents as their main teachers (Ohmagari and Berkes, 1997). Although their study of the transmission of traditional food procurement techniques examined peasants, Ruddle and Chesterfield (1977) also found that parents were the primary teachers. Shennan and Steele (1999) expressly argue that skill transmission is a form of parental investment. In a survey of over a dozen cultures of varying complexity, they found that transmission of craft skills was most often from parent to child. There are some noteworthy exceptions to this rule: among the Hadza, for example, boys "almost never go hunting with their fathers" (Marlowe, 2010, p. 157), learning instead through a combination of practice and observation of older boys.

Several lines of evidence suggest that foraging knowledge takes considerable time to acquire and refine. Hewlett and CavalliSforza (1986) found that, by age 10, the majority of Aka children have acquired most of the skills they need to survive in the forest. However, certain key skills are not mastered until the mid-teens. At age 10, 13% of girls and 0.0% of boys report having mating skills, whereas at age 15, 100% of girls and 94% of boys report having these skills. At age 10, 69% of girls and 36% of boys report having infant care skills, whereas at age 15, 84% of girls and 70% of boys report having these skills. During this same period, boys also increase their net hunting and other hunting skills: at age 10, 75% have net hunting and 28% have other hunting skills, while at age 15, 96% have net hunting and 63% have other hunting skills. This latter finding is important given our species' dietary dependence on nutrient-dense foods to support the high metabolic cost of brain growth and maintenance (Leonard et al., 2007), and the importance of hunting in obtaining these foods. Other studies report similar ages for indigenous skill acquisition. For example, among the James Bay Cree, the mean age of transmission was 14 in Moose factory and 11 in Peawanuck; older Cree women reported that they had learned the same skills by the age of 13–15, and had mastered all bush skills before the age of marriage (Ohmagari and Berkes, 1997, pp. 209–210). These findings are consistent with ethnographic research indicating that Cree children had the skills requisite to surviving in the bush by the time they reached their mid-to-late teens (Rogers and Rogers, 1960; Flannery, 1962; Blythe et al., 1985). Ruddle and Chesterfield (1977, p. 104) report similar findings for Venezuelan peasants. Observations of single-skill acquisition, too, suggest that mastery takes years of practice. For example, Mer children begin spearfishing as soon as they begin walking, yet it is not until between the ages of 10 and 14 that those "children that choose to invest in spearfishing practice reach the same efficiency as the most practiced adult" (Bliege Bird and Bird, 2002, p. 262). Waorani boys can consistently hit leaf and fruit targets with a blowgun at age 5, but do not become proficient until their late teens (Yost and Kelley, 1983).

The embodied capital hypothesis is supported by comparative evidence that primate foraging is cognitively demanding (Menzel, 1997) and ethnographic evidence

that successful exploitation of the foraging niche requires extensive zoological, botanical, and geographical knowledge (Laughlin, 1968; Blurton Jones and Konner, 1976). For example, the Aka exploit 63 plant species, 20 insect species, honey from 8 species of bees, and 28 species of game, the latter of which requires knowledge of several capture techniques (e.g., spear, net, crossbow, snare, trap; Hewlett, 1991). Similarly, the Ache utilize a minimum of 78 mammal species, 21 reptile and amphibian species, 150 bird species, and 14 fish species (Kaplan et al., 2000, p. 171). Like hunting, gathering requires extensive knowledge. Among the Washo, for example, efficient gathering "requires a vast fund of knowledge about the growth cycle of dozens of plant species, [and] an understanding of the effect of weather on growth and knowledge of soils and growing conditions" (Downs, 1966). Among the !Kung, "knowledge of plant identification, growth, ripeness, and location... is extremely complex" and "!Kung women are highly skilled at distinguishing useful from non-useful or dangerous plants and at finding and bringing home sufficient quantities of the best food species available" (Lee, 1984, p. 37). The use of food storage to survive predictable annual shortfalls creates additional information demands, such as "boning, drying, salting, and smoking as well as the use of specialized tools" (Kramer, 2005b, p. 227). Hunting and gathering also require extensive topographical and wayfinding knowledge: many foraging groups utilize more than 1000 km2 in the course of a year (Kelly, 1995, pp. 112–115). The James Bay Cree are a case in point: "a knowledge of fish distributions and behavior, *as well as the ability to navigate the coast* are prerequisites to successful fishing" (Ohmagari and Berkes, 1997, p. 200, emphasis added). Indeed, traditional Cree and Inuit knowledge of seasonal cycles, rivers, currents, sea ice, and the food web is so extensive that it has been used to aid in assessments of sustainable resource development in the Hudson Bay region (McDonald et al., 1997).

Perhaps the most impressive display of forager knowledge is seen in tracking. From the angle at which urine has landed on snow, a Beaver hunter can tell whether the moose he is stalking is a cow or a bull; from the distances between hoof marks, he can infer the animal's speed; and from the texture and shape of a hoof mark or droppings, he can tell how long ago an animal passed through an area (Brody, 2002).!Xo trackers were able to tell that "the spoor leaving the sleeping place had been made early that morning and was therefore relatively fresh. The spoor then followed a straight course, indicating that the animal was on its way to a specific destination" (Liebenberg, 1990, p. 80). When they came upon several sets of footprints all in the same area, one tracker determined "that these footprints all belonged to the same animal, but were made during the previous days. He explained that the particular area was the feeding ground of that particular wildebeest. Since it was, by that time, about midday, it could be expected that the wildebeest may be resting in the shade in the near vicinity" (Liebenberg, 1990, p. 80).

Ethnographic evidence suggests that forager education begins early. As noted above, Mer children begin spearfishing as toddlers (Bliege Bird and Bird, 2002) and Waorani boys are using blowguns by age 5 (Yost and Kelley, 1983). Similarly, Hadza boys

are given their first bows at age 3 (Marlowe, 2010). Cree children began learning as soon as they could walk and started helping with work around camp (Long, 1978). Mardudjara children began accumulating foraging knowledge at very early age (Tonkinson, 1978), and most Ache "children have detailed knowledge of resource characteristics and capture techniques before ever foraging themselves" (Kaplan and Hill, 1992, p. 196). Chagnon (1997) observes that Yanomamö children are "accomplished naturalists" (130) at an early age – for example, that most 12-year-old boys can name 20 species of bees, give anatomical or behavioral reasons for their distinctions, and tell which ones produce the best honey. Similarly, "any 12-year-old [!Kung] boy can accurately reproduce in the sand the prints of a dozen species" (Lee, 1984, p. 47). However, an incident reported by Helena Valero (a Brazilian woman who was captured by the Ya¸nomamö) suggests that, although children's foraging knowledge may be considerable, it is not exhaustive. During Valero's captivity, a little girl died and another became ill from eating the eggs of a poisonous toad. An older woman scolded the sick girl: "So you don't know that the eggs of that toad are poisonous? When I was with the Namoeteri five children died after eating the eggs of that toad.... We had gone to pick *mumu*, and the children, who stayed behind with only the old women, had cooked the toad's eggs" (Biocca, 1970, p. 86). Unfortunately, these observations are anecdotal and therefore inconclusive. Because there are so few systematic studies of forager knowledge transmission, it is not clear how or when children master this body of knowledge.

In some habitats, the age at which children begin acquiring foraging skills is limited by local ecology. Some skills can't be taught until the child has sufficient stamina to travel long distances, sufficient patience to endure discomfort, and/or sufficient strength to manage heavy loads or animals. For example, although acquisition of foraging knowledge began in early childhood, Mardudjara men did not take their sons hunting with them until they were mature enough to travel long distances and endure the tension of stalking game without detection (Tonkinson, 1978). One Dunne-za informant reports that kids start to go on hunts "After they're about the same size Joe, you know [age 10]. Just enough to think, you know. To talk, and think. Walk" (Ridington, 1988, p. 170). Netsilingmiut boys did not begin to learn breathing-hole seal hunting until between the ages of 12 and 14 (Rasmussen, 1931), presumably because of the strength required to haul in a seal and the endurance required to lie still on the ice in frigid temperatures for hours at a time. In some environments, foraging is simply too dangerous and/or difficult for young children, which constrains their opportunities for acquiring certain skills until they are older.

Blurton Jones et al.'s (1994) comparison of !Kung and Hadza children's foraging illustrates this point. The Kalahari Desert is characterized by high temperatures, little water, predators, and thorny plants. Hunting and gathering excursions may take adults far from camp, and the days are hot 8 months out of the year. Due to the flat featureless terrain and thick brush, a child who falls behind or wanders off is likely to get lost, which is very dangerous: children are much more vulnerable to heat exhaustion, cold, starvation, and predation than adults. Not surprisingly, !Kung parents regard children

as a hindrance to hunting and gathering. Children over age 3 rarely accompany women on gathering forays: a woman can't carry an older child who gets tired, because she is usually carrying an infant or toddler, in addition to whatever she has gathered. These problems are exacerbated in the dry season, when there are no water sources en route to gathering sites. Although there is no direct research on !Kung children's mastery of foraging skills, children's contribution to subsistence gives some indication of when this occurs. According to Draper (1976),/Du/da !Kung children make virtually no economic contribution to subsistence: boys do not begin serious hunting until age 16 or older, and girls do not begin regular food, water, and wood gathering until around age 14 (see also Draper and Cashdan, 1988). !Kung marriage practices suggest that gathering skills are not mastered for several years. Traditionally, !Kung girls were married between the age of 12 and 16 but, due to the practice of bride service, effectively remained at home until they were older. One reason the !Kung give for the practice of bride service is that "a girl of 12 or 14 was simply too young to leave her parents" (Lee, 1984). The fact that/Du/da !Kung girls don't begin gathering until age 14 suggests that they continue to live with their parents after marriage because their foraging knowledge is incomplete.

In contrast to the Kalahari, the Hadza environment has ample shade, salient landmarks, panoramic vistas, and sufficient dry season water sources. These features greatly reduce the danger of heat exhaustion and the chances of getting lost. Accordingly, Hadza children are allowed to play and forage on their own, and may spend several hours a day away from camp (Blurton Jones et al., 1994). Similarly, Martu children begin foraging on their own without parental supervision at a very young age (Bird and Bliege Bird, 2005). Bird and Bliege Bird found that the *winyjikity* goanna return rates for younger (age 5–7) Martu children were not significantly different from those of older (age 12–14) children, and conclude that, "Beyond about 5 years, age alone has little effect on children's hunting success in rocky outcrops" (142). Although this research appears to indicate that foraging competence is swiftly achieved, the range of skills examined in these studies is quite narrow. For example, Bird and Bliege Bird (2005) only examined the harvesting of one wild resource (i.e., hunting *winyjikity* goannas) in one location (rocky outcrops). The exploitation of other resources and ecological zones may require a much longer learning period. Also, participants drove to field camps and in some cases to foraging locations, which removed the route selection and navigation tasks normally associated with hunting and gathering. Topographical information – e.g., the distribution of resources across the landscape, their season(s) of availability, their location relative to travel routes – is unlikely to be acquired by hunting in rocky outcrops close to camp, or to be mastered by age 5. Aboriginal children are able to capture small game and gather grubs and fruit, but they remain dependent on their parents for foods with higher capture and processing costs (Gould, 1980). A Martu woman's memories of her childhood foraging experiences illustrates this point:

> Mothers and fathers gone out hunting and leave us kids in camp. When we got hungry we go hunting for little lizard, get him and cook it and eat him up. Me little bit big now, I go hunting myself, tracking goanna and kill him.... Soon as mother leave him, little ones go hunting, kill animals, blue tongue, mountain devil, take them home before mother and father come back, cook and eat it. Mother come back and feed all them kids.... Morning again, father one he go hunting.... He been get and kill an emu, bring and cook him. Everyone happy, they bin say he good hunter. (Napanangka, 1995, p. 143)

As Konner (2010) astutely observes, the informant's references to mother feeding all the kids and father being a good hunter "show that the children did not really fend for themselves" (645). In sum, in low-risk environments with abundant easy-to-harvest foods, children may make considerable contributions to their subsistence (Bliege Bird and Bird, 2002; Kramer, 2002, 2005a,b; Tucker and Young, 2005). However, children's foraging return rates for single or a small subset of resources are not a proxy for breadth and depth of foraging knowledge.

Turning this observation on its head, Tucker and Young (2005) argue that children's contributions to their caloric intake are not an accurate measure of their maximum f oraging potential, which makes it difficult to pinpoint the terminus of juvenile dependency. This point is made in the context of Mikea children's specialization in a high-quality, easily extracted resource: the *ovy* tuber. Tucker and Young suggest that Mikea children could provide most of their caloric needs, but choose not to. However, the Mikea forest is an exceptionally safe foraging habitat for children; thus, Mikea children do not face the information demands associated with avoiding dangerous animals, exposure, heat exhaustion, and other environmental hazards. Moreover, although *ovy* is "the most important foraged food source" (Tucker and Young, 2005, p. 152), the authors identify at least 23 other wild foods included in the Mikea diet, begging the question of when Mikea children master the skills needed to harvest them. High foraging return rates (measured in calories) have been documented among Hadza children as well. However, most of these calories are acquired on trips to distant berry patches with adults (Hawkes et al., 1995, p. 694); thus, these children are largely spared the tasks of route finding, predator detection, and remembering patch location(s).

Bird and Bliege Bird (2005) add another turn of the screw by noting that, because it is an indirect measure, foraging efficiency does not tell us exactly how long it takes children to acquire a given foraging skill. While true, this observation misses the larger point that successful exploitation of the foraging niche requires a "basket of competencies" (Bock, 2002, p. 168) that are interdependent and additive. A given competence may be mastered early and/or quickly, but its successful deployment may require recruitment of other competencies that do not come online or are not mastered until later in life. As Blurton Jones and Marlowe (2002) note, "The difference between being

a good archer and being a successful hunter may be very large; hunting benefits from extensive knowledge and requires several skills" (229).

Measuring children's contributions to their subsistence in calories is also problematic in that it does not indicate whether children's foraging returns meet their nutritional needs. For example, Hadza children's mean in-patch acquisition rates for two types of berries (*tafabe* and *ondishibe*) are 2223 and 964 cal/h, respectively – about 50–70% of adult rates (Hawkes et al., 1995). Based on this finding, the authors argue that Hadza children "could earn their own daily consumption requirements in less than 3 h once they reached the patch" (693). However, no amount of berries will provide sufficient fat or protein for a growing child, nor is it likely to provide all necessary vitamins and minerals. Another Hadza study estimates that, "If children spent just 2 h per day foraging for baobab, or (for older boys with access to an axe) honey, they would acquire around 800–1000 cal, almost half the calories they need.... Thus it is quite possible that Hadza children from the age of about 5 years old provide half of their food by their own efforts" (Blurton Jones et al., 1989, p. 380). While high foraging return rates among dependent children may contribute to shorter inter-birth intervals for mothers, a child who provides half of his/ her daily calories is by no means economically independent, and a diet of baobab and/or honey cannot supply the fatty acids requisite to brain growth at this stage of life (Leonard et al., 2007). On this point, the authors observe that Hadza boys age 10 and older can and do shoot birds and small animals, "but this was not a significant part of their diet" (Blurton Jones et al., 1989, p. 379). However, the authors only followed children during the dry season; there may be seasonal variation in Hadza boys' hunting and in Hadza children's gathering returns in general.

Although researchers disagree over whether the comparatively low productivity of forager children is due to insufficient size/ strength or insufficient knowledge, research indicates that both factors are involved. Both within and across habitats, economic tasks vary in the degree of strength, skill and knowledge they demand. This variation may be parsed in terms of easy-to-harvest *collected* resources (e.g., fallen fruit) versus difficult-to-harvest *extracted* resources (e.g., large game; Kaplan et al., 2000). In studies that find high foraging return rates for children, the targeted resource(s) tends to fall into the former category (e.g., Hawkes et al., 1995; Bliege Bird and Bird, 2002; Bird and Bliege Bird, 2005; Tucker and Young, 2005). Moreover, as noted above, these high rates tend to occur either in exceptionally safe, easily navigable habitats (e.g., Blurton Jones et al., 1994; Bliege Bird and Bird, 2002; Bird and Bliege Bird, 2005; Tucker and Young, 2005) or when children forage in the company of adults (Hawkes et al., 1995) – conditions that spare children the tasks of remembering resource locations, route finding, and/or avoiding environmental hazards, and thus belie the "ease" with which these resources are harvested.

More importantly, humans do not live by collected resources alone. Harvesting extracted resources typically involves a suite of skills, some of which may be acquired relatively quickly (e.g., marksmanship), and others of which may take years to master (e.g., locating and successfully capturing game; Blurton Jones and Marlowe, 2002;

Walker et al., 2002; Gurven et al., 2006). As Bock (2002) argues, for any given task, two aspects of technology potentially come into play: the strength needed to effect it and the knowledge and/or skill needed to deploy it. For example, picking up nuts may seem simple, but carrying them takes strength and finding them takes knowledge. A !Kung woman may walk 16 km per day carrying a full day's harvest and a child. She needs to know where foods are to be found, and in what season they are edible; how to keep oriented in the bush (5- and 6-year-old !Kung children cannot do this; Blurton Jones et al., 1994); and how to read animal tracks. The latter skill is integral to avoiding dangerous animals (e.g., lions, leopards, elephants, snakes) while gathering. On this point, !Kung women are able to tell whether a given snake species is dangerous or not, and how it reacts to the presence of humans. While gathering, !Kung women also make note of animal tracks and report recent game movements to the men when they return to camp. Once gathered, foods may require processing, which may take both strength and skill. For example, although a certain amount of strength and coordination are needed to crack mongongo nuts effectively, peak efficiency takes "some years to acquire after adults stop growing" (Bock, 2002), suggesting that knowledge affects efficiency. Thus, gathering nuts is not a simple matter of being able to carry a heavy load.

Bock's (2005) study of fishing among San and Bantu boys and girls in the Okavango Delta illustrates this point by teasing out the relationships between size, experience, and children's foraging returns. His findings support the claim that childhood is a period of both strength and knowledge acquisition. He found that, for girls' basket fishing, arm strength does not significantly affect the quantity of fish caught. Variation in fishing returns is due to age (i.e., experience, knowledge) alone: older girls catch more fish. In contrast, arm strength, not age, is a predictor of size (mean weight) of fish caught: stronger girls catch bigger fish. This is because catching larger fish requires a larger basket and the strength to move the basket through deep water. Bock concludes that age (experience) is important in knowing where to find fish, whereas strength is integral to catching larger fish. For boys' canoe fishing, Bock found that arm strength, not age, is predictor of quantity of fish caught: stronger boys catch more fish. This may be related to the ability to pole a canoe close to the reed beds, which requires poling a long distance through deeper water. In contrast, age, not arm strength, is a predictor of size (mean weight) of fish caught: older boys catch bigger fish. Bock concludes that stronger boys can pole a canoe close to the reeds, whereas more experienced boys may have greater knowledge of where to find big fish and/or how to use hook and line.

In sum, in order to understand why prolonged juvenility evolved in humans, it is critical to determine when children master the full spectrum of skills it takes to be a competent forager. In so doing, it is important to include not only subsistence skills *per se* (e.g., arrow shooting, fish jigging, tuber digging), but skills that scaffold foraging (e.g., wayfinding, tool manufacture, predator avoidance), including skills that are integral to navigating the social world (e.g., sharing, mating, infant care). Research indicates that, at least in some habitats, it takes many years to reach peak foraging

efficiency (Ohtsuka, 1989; Kaplan et al., 2000, 2003; Kaplan and Bock, 2001; Bock, 2002; Walker et al., 2002; Gurven et al., 2006), and juvenile consumption exceeds production until the late teens or older (Kaplan and Robson, 2002; Robinson et al., 2008). However, as noted above, foraging efficiency is an indirect measure and does not tell us exactly how long it takes to learn these skills. With regard to the question of whether and to what degree parents invest knowledge in their children, it would be useful to know how much forager children learn on their own, and how much they learn from adults. Unfortunately, there is no data on these groups comparable to Hewlett and Cavalli-Sforza's (1986), showing the age at which children master a representative sample of foraging skills and how they acquire them. Despite this lack, cross-cultural ethnographic evidence suggests that successful occupation of the foraging niche requires extensive knowledge, that at least some of this knowledge is transmitted from parents to children, and that mastery of the "basket of competencies" is not attained until the mid-teens – more or less the length of the extended juvenile period.

The role of learning in the foraging niche

The question at the heart of the prolonged juvenility debate is not whether children learn during childhood, but whether learning is a cause or consequence of the extended juvenile period (Bock and Sellen, 2002; Hrdy, 2005; Konner, 2010). Although presented as alternative processes, they are most likely complementary. Human infants are born when the brain is only 25% of its adult size, and are incapable of supplying the energy needed to complete the growth process. Moreover, neural tissue is metabolically expensive to grow and operate, commandeering 87% of resting metabolic rate in infancy and 20–25% in adulthood (Leonard et al., 2007). Thus, brain expansion could not have been selected for in the absence of either, increased provisioning/protection or compensatory benefits. On this view, extended provisioning of offspring and encephalization are tandem processes, each driving the other in a 2-million-year-long feedback loop. In the course of this process, some parts of the brain were enlarged more than others. These areas include the cerebellum, neocortex, basal ganglia, and hippocampus (Stephan et al., 1981), all of which are integral to learning processes. Thus, it appears that brain expansion was driven, at least in part, by selection for increased learning capacities. This hypothesis is supported by extensive research in developmental psychology showing early onset of a host of domain-specific cognitive systems that guide attention to relevant stimuli and organize informational inputs (for a review, see Carey, 2009).

A sizeable portion of this cognitive equipage appears to be dedicated to mechanisms for social learning: to a greater degree than other species, humans appear to be designed to acquire information from conspecifics (Byrne, 1995; Tomasello, 1999; Tomasello et al., 2005). Perhaps the most compelling evidence in support of this claim is shared attention, which appears to be unique to humans (Baron-Cohen, 2005) and emerges

predictably near the end of the first year (Scaife and Bruner, 1975; Butterworth and Cochran, 1980; Leslie, 1994; Baron-Cohen, 1995, 2005; Carpenter et al., 1998b) – well before infants have mastered the art of walking. This is what we would expect if social learning were integral to occupation of the foraging niche and if learning took a long time. If humans could quickly accumulate all knowledge requisite to success in their ecological niche, there would be no need for the structures that subserve learning to develop early.

In addition to shared attention, learning from others requires shared intentionality: the ability to attribute a goal to an individual, to understand how the individual's actions subserve his/her goal, and to make the extrapolation, "When I have the same goal I can use the same means" (Tomasello et al., 2005, p. 680). This capacity emerges by about 14 months, and is neatly illustrated in Meltzoff's (1995) study of imitation in 18-month-old infants. Subjects were presented with two types of demonstrations. In the first condition, infants watched an adult perform actions on objects, whereas in the second condition, infants watched an adult try but fail to perform actions on objects (e.g., try but fail to pull apart two parts of an object). Both groups reproduced the target actions equally well. Tellingly, in Condition 2, infants appeared to understand what the adult was trying (i.e., intended) to do and performed that action instead of mimicking the adult's actual behavior. In a related study, Carpenter et al. (1998a) examined 14- to 18-month-old infants' imitation of accidental versus intentional actions. Infants watched as an adult performed two-action sequences on objects. One action was marked vocally as intentional ("There!"), and one action was marked as accidental ("Woops!"). Infants were then given the opportunity to make the result occur themselves. Infants imitated twice as many intentional actions as accidental ones regardless of the order in which they saw them. Gergely et al. (2002) report an even more sophisticated understanding of the relationship between intention and action. In this study, 14-month-old infants watched as an actor used his head to turn on a light in either a hands-free or a hands-occupied condition. When given the opportunity to turn on the light themselves, subjects who saw the hands-free condition used the head method more often than infants who saw the hands-occupied condition. These results suggest that infants in the hands-occupied condition assumed that the actor wouldn't have used his head if his hands had been free. Conversely, infants in the hands-free condition appear to have assumed that the actor had a reason for using his head instead of his hands. These studies suggest that infants infer the goal of an actor, and use this representation to replicate that goal.

Shared intentionality is also integral to language learning (Tomasello et al., 2005) and thus to the acquisition of knowledge via linguistic communication. As Baldwin et al.'s (1996) "dawnoo" experiment illustrates, language acquisition is dependent on the ability to understand what a conspecific intends ("means") by an utterance. In this study, toddlers (19–20 months) were shown a novel object while a speaker simultaneously produced a novel label (e.g., "A *dawnoo*!"). In the first condition, the speaker was seated next to the infant and looking at the novel object when the novel label was

vocalized; in the second condition, the speaker was seated out of sight of the infant. Infants in the first condition readily chose the correct object over an equally salient distractor object when they were later asked to find the *dawnoo*. In contrast, infants in the second condition were just as likely to choose the distractor object as the correct object. Baldwin's (1993) team concluded that toddlers are capable of understanding that speakers intend to talk about objects and of using this understanding to acquire new information – in this case, to learn new object–word associations.

Pinpointing the developmental onset of the mechanisms involved in social learning is important because, as noted above, their early emergence suggests that social learning is integral to occupation of the foraging niche. It also suggests that assembly of these mechanisms – including information input – takes a lengthy period of time. However, this is only a supposition unless we know when development of these capacities is complete: to understand the relationship between learning and the evolution of prolonged childhood, we need to understand how long learning takes. Thus, it is critical to identify not only the age of *onset* of learning systems, but also the age of *maturity*. At this point, the amount of time required for complete assembly of these mechanisms is largely unknown – a lack that parallels the paucity of ethnographic data on the time frame for acquisition of essential knowledge sets among foragers.

To illustrate this point, consider three knowledge sets critical to success in the foraging niche: information about the social environment, animal behavior/characteristics, and topography. Acquisition of social information is subserved, in part, by the mindreading system. Research indicates that mindreading involves several different capacities, with different developmental trajectories (e.g., Leslie, 1994; Baron-Cohen, 2005). For example: the ability to represent affective states emerges at around 3 months (Walker, 1982); the understanding that an entity with eyes can perceive emerges between birth and 9 months (Baron-Cohen, 2005); the ability to represent goal-directed action emerges between 5 and 7 months (Woodward, 1998; Csibra et al., 1999; Hamlin et al., 2007); shared attention emerges by 12 months (Scaife and Bruner, 1975; Butterworth and Cochran, 1980; Carpenter et al., 1998b); and the understanding that seeing-leads-to-knowing emerges by 15 months (O'Neill, 1996; Onishi and Baillargeon, 2005). Pretense, too, appears to develop in stages: pretend-play emerges between 18 and 24 months, but the understanding of pretense (i.e., recognizing when others are engaging in it) emerges by 15 months (Onishi et al., 2007). Thus, the mindreading system is additive, involving the successive assembly and integration of multiple components over time. This assembly is assumed to be complete when children can understand that others can have beliefs that are different from theirs and that these beliefs can be false (i.e., *false belief*). However, mindreading development does not end with the ability to understand the behavior of others in terms of epistemic states. The mindreading system cannot be considered complete until it can be used to construct a reliable, integrated "social map of the persons, relationships, motives, interactions, emotions, and intentions" in the individual's social environment (Cosmides and Tooby, 1992, p. 163). Just as a spatial map represents the relative positions of a given set of entities, a social

map represents the motives, emotions, and intentions of individuals *in relation to one another*. In order to make such a map, a person must be able to (1) note and remember the actions performed by a specific individual; (2) determine which of the individual's actions subserve which of the individual's goals (i.e., infer the individual's plans for attaining his/her goals); (3) integrate this representation with representations of the goals and actions of the other individuals in his/her social world; (4) identify points of conflict between the goals of these individuals; and (5) track the outcomes of these conflicts (Scalise Sugiyama, 2009). In short, mapping one's social world requires the ability to track interactions between multiple lines of goal-directed action. The question of when this capacity develops is an open one.

On this point, children's acquisition of narrative competence is illustrative. Story plots trace the conflicts between characters' goals and the outcomes of those conflicts (Scalise Sugiyama, 2005, 2009). Thus, narrative processing entails tracking interactions between multiple lines of goal-directed action – i.e., the construction of a social map of the story world. Interestingly, children's early narrative is organized by a central theme rather than a plot (Sutton-Smith, 1986). After age 3 or 4, story focus shifts from a central theme to a central character, but conflict – a central goal and opposition to that goal – is still absent. Central characters with a clear conflict do not appear regularly until somewhere between age 5 and 7. Children "can state a conflict before they can develop and resolve it" and do not master the latter ability until as late as age 10 (Sutton-Smith, 1986, p. 82). Thus, plot structure consists of several components, which children appear to master in stages: (1) organization around a central character, (2) with a clear goal, and (3) obstacles to the attainment of that goal (including goals of other characters). Of course, children's acquisition of narrative competence cannot tell us when the ability to track multiple lines of goal-directed action emerges, as development of this ability may precede development of the linguistic skills requisite to expressing it. However, children's narrative development shows that mapping the social world requires the ability not only to attribute mental states to others, but to chart the mental states of multiple individuals as they converge and/or collide with one another in an endless series of moves and countermoves. Little is known about the design or ontogeny of the cognitive structures involved in this task. Additionally, because social environments vary across locales, mapping them requires local information inputs. Yup'ik girls' storyknifing (oral narrative accompanied by drawings sketched in mud with a knife) suggests that storytelling may be a source of these inputs. Among other topics, participants "tell about the people they saw during the day and where they fit into the kinship system. Often, one girl will have information that corrects or supports another's account. The stories may explain why a member of the community is known by a particular nickname, to which family a woman belonged before her marriage, or how certain people are related to others. The stories are a means by which the girls can work together to construct the kinship system of the community" (de Marrais et al., 1994, p. 202). Participants in de Marrais et al.'s (1994) study ranged in age from 9

to 12, but it is not known when children acquire a comprehensive map of their social world.

Another key foraging knowledge set is information about dangerous animals and how to avoid them. Evidence suggests that at least some of the cognitive mechanisms that scaffold this task begin emerging early in development. For example, humans appear to have evolved intuitive ontologies (Spelke et al., 1992; Wellman and Gelman, 1992; Carey, 2009) – cognitive structures that categorize entities in the world by the properties they have in common. These ontological categories are invaluable for making valid inferences. For example, putting *jaguar* in the "agent" category activates the inferences "eats," "periodically experiences hunger" and "is capable of goal-directed action," which have obvious fitness benefits for the individual making them. A number of studies suggest that the agency system contains *intentional schemas* – inference systems activated under specific conditions – which are used to predict the behavior of agents (Gergely et al., 1995; Csibra et al., 1999), including animal predators (Csibra et al., 2003; Barrett, 2005).

However, finer-grained predictions of animal behavior require knowledge acquisition as well as inference (Barrett, 2005). Boyer's (2001) "template" model of knowledge acquisition illustrates the interdependence of conceptual primitives (e.g., innate ontological categories) and environmental input (e.g., learning). Boyer proposes that the acquisition of knowledge about entities in the world is guided by cognitive structures – templates – that specify the general attributes of the category to which that entity belongs (e.g., person, animal, natural object, tool). Thus, the animal template specifies the general attributes of animal agents (e.g., eats, reproduces, occupies a specific habitat), and the particulars of a given species' attributes are fleshed out as relevant information becomes available over the individual's lifespan. Initially, a child may only know a species' name – e.g., "jaguar." Then, as additional information is acquired, it is plugged into the appropriate slot. For example, the information that jaguars attack and eat humans would be added to the slot for "diet." Thus, while ontological categories and at least some intentional schemas (Gergely et al., 1995; Csibra et al., 1999, 2003) emerge early and reliably in development, full assembly and calibration of these systems requires informational inputs from the local environment. The age by which this occurs is unknown. Nor do we know the degree to which information inputs are provided through verbal transmission. Answers to these questions are critical to determining when learning is complete.

A third critical foraging knowledge set is wayfinding information. Navigation is integral to nearly every facet of forager life: locating food, water, and shelter; avoiding predators, dangerous conspecifics, and inanimate hazards; and mate acquisition (Silverman and Choi, 2005). This raises the question: at what age is this capacity sufficiently developed for an individual to cognitively map the distribution of resources and hazards across the landscape and travel long distances through this landscape without getting lost? Psychological research indicates that children begin to navigate by landmark around age 2, but do not use orientation (dead reckoning) strategies un-

til age 8 (Anooshian and Young, 1981; Scholnick et al., 1990; Blades and Medlicott, 1992). Once again, however, we must not confuse onset with maturity. Navigating by landmark requires informational input (i.e., knowledge of landmarks in one's local environment) and, given that many forager groups maintain knowledge of more than 1000 km2 (Kelly, 1995, pp. 112–115), this information may take years to acquire. Given the wide range of latitudes occupied by our species, dead reckoning mechanisms may similarly require local environmental inputs for assembly and calibration (i.e., to local and seasonal variation in the sun's zenith, hours of daylight, etc.).

What do humans learn from storytelling?

Stories as a supplement to episodic memory

Narrative is a highly memorable verbal format (Sperber, 1985); as such, it might plausibly be used as a means of storing and transmitting foraging knowledge. Due to this verbal nature, however, storytelling is better suited for transmitting certain kinds of information than others. For example, the motor skills required for spear throwing, basket weaving, and using a fire drill are best developed through practice. In the ethnographic literature, it is commonly observed that storytelling is used to transmit cultural prescriptions and proscriptions. For example, the oral tradition "is of greatest functional importance to the Jicarilla in the guidance of his behavior, his beliefs, and his ceremonies.... The mythology represents for him the summation of knowledge on the basis of which he must act" (Opler, 1940, p. x; see also Goodwin, 1939; Street, 1972; Biesele, 1993; de Marrais et al., 1994; Scalise Sugiyama, 2008). Forager oral traditions also appear to serve as a repository for information relevant to recurrent problems of forager existence, such as manipulating and being manipulated by others (Scalise Sugiyama, 1996), locating and harvesting resources (Scalise Sugiyama, 2001a,b), famine (Sobel and Bettles, 2000; Scalise Sugiyama and Sugiyama, 2009), predator avoidance (Scalise Sugiyama, 2004, 2006), free riding (Scalise Sugiyama, 2008), wayfinding (Scalise Sugiyama and Sugiyama, 2008), and errant children (Scalise Sugiyama and Sugiyama, in press). Research on mental time travel – the ability to recall the past and imagine the future – provides a framework for integrating all of these claims.

Schacter et al. (2007) argue that our ability to plan (i.e., imagine future scenarios) is rooted in episodic memory (recall of personal experience). Noting that event simulation is useful for planning for the future, they argue that the function of episodic memory is to generate simulations of possible future events. Specifically, our memory of past experiences provides events out of which possible future scenarios are constructed. This hypothesis is supported by clinical research showing that memory impairment compromises patients' ability to imagine future scenarios, and by neuroimaging research pointing to a Core Brain System that is activated while remembering the past and

imagining the future. Marshall's description of !Kung conversation patterns provides a striking behavioral illustration of the connection between remembering and planning in daily life: "The men's imaginations turn to hunting. They converse musingly, as though enjoying a sort of daydream together, about past hunts, telling over and over where game was found and who killed it. They wonder where the game is at present, and say what fat bucks they hope to kill. They also plan their next hunts with practicality" (1976, p. 352). The men's discussion slips seamlessly from episodic memory (*where game was found*) to possible scenarios (*where game is at present*) to possible future scenarios (*fat bucks they hope to kill*).

If past experience provides the raw material for constructing future scenarios, then increases in experience should lead to increases in the range of future scenarios one is able to imagine, as well as improvements in their detail and accuracy. Unfortunately, acquiring experience at first hand can be difficult, time-consuming, and/or dangerous. Animal knowledge is a case in point: how do young children learn the salient characteristics of different animal species, their behavior patterns, and the habitats with which they are associated? Some information might be acquired by observing game brought back to camp. However, this method depends on the child seeing the game before it is butchered, and is confounded by the common practice of butchering large game at the kill site and carrying it back to camp piecemeal. Unweaned children, who typically accompany their mothers on gathering forays (Berndt and Berndt, 1964, p. 133; Goodale, 1971, p. 35; Marshall, 1976; Hames, 1988; Konner, 2005, p. 53; Marlowe, 2010), may have the opportunity to observe animals both en route to/from and at the foraging patch. However, research shows that children's attention at this age is narrow in scope: infants and toddlers overwhelmingly attend to and manipulate small objects close at hand (Garvey, 1990; Chase, 1992) and play within 200 feet of their caregivers (Anderson, 1972; Draper, 1976; Konner, 1976; Hurtado et al., 1992; Hill and Hurtado, 1996). This preference is not due to poor visual acuity, which reaches 20/20 by age 2 (Heerwagen and Orians, 2002). Weaned children, on the other hand, are typically left in camp while parents forage. The likelihood of seeing animals in camp is low (Heerwagen and Orians, 2002), as is the range of animal species likely to be observed. Thus, young children's opportunities for observing animal behavior are limited and – due to their small size and lack of experience – fraught with risk (Scalise Sugiyama, 2001a; Barrett, 2005).

Information exchange offers a proactive, safe, readily available solution to this problem by enabling children to acquire information about a given experience in the absence of the actual experience and before the information is actually needed (Scalise Sugiyama, 2001a). This practice is maintained in modern environments, in which children are exposed to animal behavior under highly controlled, low-risk circumstances, such as picture books, television, and zoos. Narrative is particularly well-suited to the expansion of experience because it simulates the human environment – agents, actions, and environmental constraints on action (including other agents) – enabling individuals to "watch" the goals and actions of a given set of agents play out under a given

set of circumstances (Scalise Sugiyama, 2005). Because narrative "mimics the format in which experienced events are mentally represented and stored in memory" (Tooby and Cosmides, 2001, p. 24), stories enable us to make the experiences of others our own, and add them to our episodic memory. Furthermore – with all due respect to the powers of the mindreading system – in narrative we are truly privy to what others perceive, think, feel, intend, and desire, in that a story typically includes "one or more persons [characters] from whose perspective we can vicariously experience the receipt of information" (Tooby and Cosmides, 2001, p. 24). Thus, depending on the narrative point of view, we experience story events not only from our own perspective but (potentially) from the perspectives of others. In other words, the "experience" contributed by narrative to episodic memory includes ego's observation of events as well as ego's observation of characters' observations of events. Through storytelling, then, parents can safely, efficiently, and exponentially expand their children's life experience and episodic memory, thereby enabling them to construct a wider range of alternative perspectives and scenarios. In life history terms, storytelling is a means by which parents can invest in the embodied capital of their offspring: narrative is a format *par excellence* by which the brain can "transform present experiences into future performance" (Kaplan and Gangestad, 2005, p. 74).

The facts about fiction

The claim that participating in story worlds expands personal experience may appear to be undermined by the fictional nature of much story content. How is an individual to distinguish between factual and counterfactual content and thereby avoid the pitfalls of acting on false information? (This problem applies to non-fiction narrative as well, because even "true" stories are subject to inaccurate recall and exaggeration.) The surprising answer is that, in many cases, fictional content is benign with respect to fitness. Consider the Netsilingmiut story in which a moose tricks a hunter into letting it escape. The moose has been ambushed in deep water by a man in a kayak. Realizing his peril, the moose says to the man, "Just let me get near to the bright shallow water over there, then you may stab me" (Rasmussen, 1931, p. 399). The man complies with the moose's request, and once the animal gets to the shallow water, it runs away. On a subsequent hunt, the man encounters the same moose, which attempts the same trick. This time, however, the man ignores the moose and kills it before it can reach the shallow water. The obvious factual information contained in this story is the observation that moose are harder to kill in shallow water than in deep water, and the obvious counterfactual information is that moose can talk. Interestingly, the counterfactual information is neutral with respect to the factual information: it is true that moose are more likely to elude a hunter in shallow water than in deep water regardless of whether they are capable of speech. Thus, the story provides information useful for predicting the behavior of a valuable prey species, and believing that moose can talk

does not compromise this information or impose additional costs on the acquisition of this resource.

This observation notwithstanding, humans regularly and reliably filter the factual from the fictional. This stems from our ability to represent and store information as "contingently true" – information that might be true, used to be true, might be true in the future, is true in some places but not others, is true according to some people, or is true under certain circumstances (Leslie, 1987; Cosmides and Tooby, 2000). This capacity scaffolds a host of cognitive operations, including planning: both fictions and plans are counterfactual scenarios. The ability to reason counterfactually enables humans to exploit universes of information unavailable to other species, but it also presents a formidable adaptive problem: the danger that contingently true information will get stored as true information and acted upon as such. Thus, use of contingently true information requires what Lewis (1978, p. 37) presciently called an "intensional operator" (e.g., "in story x") and what Cosmides and Tooby call "scope syntax" (2000). In order to prevent co-mingling of true and contingently true information, they argue, the latter must be "decoupled" from the former – i.e., marked with tags that delineate the scope of conditions under which it is true. Fictions are sets of contingently true propositions – counterfactual scenarios – that enable us to visualize and evaluate the possible consequences of possible courses of action. Extracting information from counterfactual scenarios that is applicable in real-world situations requires the identification of similarities between the counterfactual scenario and a real-world task. That is, the mind must be able to decouple irrelevant from relevant information. For example, "one can learn from Cordelia that overt emotional demonstrativeness is not a reliable cue to devotedness... but the reader should discard the specifics as irrelevant, rather than concluding that being named 'Cordelia' *is* a reliable cue to devotedness" (Tooby and Cosmides, 2001, p. 22).

Thus, foragers may tell stories about animals that talk or juggle their eyes or have sex with their mother-in-law, but they don't behave as if animals in the real world do these things. As Barrett (2005) observes, a Koyukon hunter may believe that if he treats the deer he has killed with respect and gratitude, it will be reborn for him to kill another day, but the many inferences that follow from this assumption are belied by the hunter's behavior: "if the deer were actually willingly sacrificing itself to the hunter, it would be unnecessary to pursue it, [and] there would be no need for the hunter to conceal himself when approaching the deer" (458). Blurton Jones and Konner's (1976) assessment of !Kung counterfactual beliefs about animals applies across the forager spectrum: such beliefs "play a small role in day-to-day !Kung life and in their interactions with animals.... [and] do not interfere with the study of animal behavior. They seem to exist in a domain of the mind quite separate from ethno-ethological knowledge" (344). Indeed, many forager oral traditions make a clear distinction between stories of the recent and distant past (Lowie, 1918; Radin, 1956; Jacobs, 1959; Biesele, 1976; Sobel and Bettles, 2000). The latter take place during an indeterminate, ancient time when "the animals were like people" (Erdoes and Ortiz, 1998, p. 12), in a world where "the

animals or birds have but to take off their skin to become human" (Parsons, 1929, p. 5) or humans are capable of "turning into animals when they get into situations in which they need the animal's characteristics" (Blurton Jones and Konner, 1976, p. 343). For example, the Winnebago divided their prose narratives into *waikan* (what-is-sacred) and *worak* (what-is-recounted). *Waikan* referred to an irretrievable past in which events occurred that are no longer humanly possible, whereas *worak* dealt with ordinary, present-day events and conditions (Radin, 1956, p. 118). Similarly, the Koyukuk tell stories set in "Myth Time" – a period "so remote that its realities are not those of today, and are not to be believed or judged in the ordinary terms of the present. That was when all Animals were Men, with the power of human speech" (1995, p. 76). A Ya¸nomamö origin story illustrates this distinction: "All the ancestors kept turning into animals, and those ancestors are here now! Today we eat those ancestors from the early times, when we Yanomam did not exist! They are animals: toucans, spider monkeys, armadillos, tapirs, giant anteaters, and jaguars.... They were Yanomam, and turned into animals" (Wilbert and Simoneau, 1990, p. 285). The metamorphosis of the ancestors is safely relegated to a distant past, and does not interfere with present-day Ya¸nomamö consumption practices.

The experiences made available by narrative are by no means limited to observations of animal behavior. Oral traditions contain information relevant to the full spectrum of daily tasks with which the forager is presented, including locating and harvesting food, resource processing, shelter construction, route finding, campsite selection, avoiding inanimate hazards, and navigating the social world. For example, Yup'ik stories transmit information about cultural norms, gender roles, subsistence strategies, and kinship (de Marrais et al., 1994). Dena stories "instruct, not only describing the characteristics of animals and birds of which the Dena should take note, but teaching the difference between right and wrong conduct" (de Laguna, 1995, p. 290). To illustrate the range of information stored and transmitted via narrative, the remainder of this section offers an overview of representative cross-cultural patterns in oral narrative content vis-à-vis recurrent information demands of foraging life.

Cross-cultural patterns in oral narrative content

Cultural anthropologists frequently observe that forager myths and folktales are a rich source of subsistence information. For example, Berndt and Yunupingu (1979) note that, even though the Arnhem Land coast is rich in food resources, "the people who lived there had to work hard to collect or catch their food. The stories helped to keep all of this information together because they tell where to find different kinds of food and how to prepare them for eating" (10). Similarly, Yup'ik stories describe how to pick berries and how to cut, dry, and smoke fish – indeed, "vegetation, the weather, the river, local animals, etc., were all integral parts of daily life stories" (de Marrais et al., 1994, p. 205; see also Opler, 1938; Ridington, 1988; Biesele, 1993; de Laguna, 1995). A Karok story about the theft of fire illustrates storytelling's richness as vector

of subsistence-related information. In this story, Coyote steals fire from the Yellow Jackets, who pursue him angrily. The fire is handed off to a succession of animals, finally coming to Frog:

> Now the Yellow Jackets had nearly caught up, when Frog was there with his mouth open. He took the fire in his mouth, made one jump, and was in the river. The Yellow Jackets could not see him. So they went home. Frog emerged and saw alders and willows growing there above him. He spat the fire out into the willow roots: then there was just a little smoke.
>
> There are only two trees that make fire well, willow at the river and cedar on the mountains....it was Buzzard who made fire on the hill....he had made it with cedar bark rubbed fine. He blew hard on the tinder, [and] it blazed up. (Kroeber and Gifford, 1980, p. 12)

This short passage contains information about an important resource, an ecological hazard, and animal behavior, characteristics, and habitat. The resource information includes types of wood suitable for making fire, where to find them, and how to use them (light the roots of willow, rub cedar bark fine, blow hard on the tinder to get the fire started). The hazard referenced is the yellow jacket, and information is provided regarding its behavior (fleet, aggressive, relentless pursuit when disturbed) and how to elude it (jump in river). By making yellow jackets the possessors of fire, the story also metaphorically references one of this animal's most salient characteristics: its painful sting, which burns like fire. Finally, the story references frog and buzzard habitat (river and hill, respectively).

Oral traditions also provide information useful to surviving periods of famine (Scalise Sugiyama and Sugiyama, 2009). For example, the Bella Coola tell how 1 year "it failed to become warm in April; the berries flowered, but the constant cold wind prevented their fruit from ripening. Few fish entered the river, and even they could not be caught because the water remained so clear. The same conditions prevailed for 4 years until the people were starving" (McIlwraith, 1948, p. 500). This passage provides information regarding the time of year when famine set in, the length of the famine period, and the resources that failed. The story goes on to identify other resources that fail, and foods that can be eaten in their stead: "Even the clams and mussels were dead, so that fern-roots and trout were the only dependable foods.... At this time there was living at Nuxwlst an unmarried woman with a child, who like everyone else, was starving. She used to support herself by hunting eels on the beach" (501). Finally, the story identifies environmental cues that can be used to locate foods that are not normally exploited: "One morning she saw a number of gulls feeding on something, and, driving them off, she found that it was a stranded porpoise. The woman returned for her basket and knife, cut up the food, and took it home" (501).

Although it is a within-culture study, Sobel and Bettles' (2000) analysis of Klamath and Modoc myth provides quantitative evidence that oral tradition contains information about subsistence stress. Based on ethnographic and historical records of famine

among the closely related Klamath and Modoc tribes, the authors predicted that these groups' mythology would contain information relevant to coping with this problem. After surveying the entire corpus of Klamath and Modoc myths, the authors selected all that explicitly or implicitly referenced subsistence stress ($n = 34$). They then compiled a list of themes related to subsistence stress (divided into five categories: subsistence stress, causes of subsistence stress, coping strategies, social exchange alliances, and shared access to harvest sites) and recorded the presence/absence of each theme for each myth in the sample. Their prediction was upheld for all theme categories. For example, 56% of myths referenced environmental and 88% referenced social causes of subsistence stress. All 34 myths referenced exchange as a means of coping with subsistence risk, while 35% referenced storage (preserving and stockpiling food for winter) and 18% referenced diversification (use of resources not normally exploited). The presence in oral tradition of information relevant to subsistence and subsistence stress is consistent with claims that linguistic communication increases foraging efficiency (e.g., Hames, 1990; Kaplan and Hill, 1992; Buckley and Steele, 2002) and may increase offspring survival rates (Fitch, 2004; Locke and Bogin, 2006).

As noted above, many foraging tasks involve wayfinding, and navigation using landmarks and dead reckoning both require local information inputs. Topographical information can be acquired through first-hand experience (e.g., as children follow their parents when moving camp) or through information exchange. Significantly, a recurrent theme in forager folklore is the origin of local topographical features (Scalise Sugiyama and Sugiyama, 2008). The Dreamtime is perhaps the best known instance of this phenomenon. These myths recount the adventures of ancestral beings who created present-day features of the Australian landscape as they traveled across the country. Collectively, these stories form a map of the territory utilized by the group, giving members a sense of the locations of important sites relative to one another (Tonkinson, 1978). This theme occurs widely across forager cultures and habitats – from the Western Desert to the Pacific Northwest, from Amazonia to the Great Plains, from Patagonia to the Arctic (Scalise Sugiyama and Sugiyama, 2008). For example, in Dena folklore, "Some places are associated with the Traveler's adventures. Thus, a hole in the rock somewhere below Rampart is where he anchored his canoe when searching for the noise in the woods; and his tracks are there, too" (de Laguna, 1995, p. 302). In a Karok story, Hakananap-manan makes the "upriver ocean" Kayurash, then decides to travel downriver: "When he came to where it flows through the rocky ridge Keichivikyuripa at Hayward's Bar, he left the river. He did not want to go further that way but widened the rocky chasm and went up the ridge on the mountains to the right, to Sihaviitka, where all the ridges meet and the streams flow down in 10 directions" (Kroeber and Gifford, 1980, p. 49). Without ever having seen these places, a Karok child could learn from this story that there is a large body of water upriver, that its outlet is navigable and passes through a rocky chasm just past a bar, this chasm is at the base of a mountain ridge, this ridge is traversable, this ridge intersects

with several other ridges, and at this intersection there are streams flowing in many different directions.

The forager oral tradition also references inanimate hazards, such as inclement weather and natural disasters. For example, "Floods have apparently killed enough Ache in the distant past that they figure importantly in Ache mythology" (Hill and Hurtado, 1996, p. 152). The Selknam tell of a woman who was gathering fish along the beach "when she perceived a dull noise, which sounded as though the earth were rumbling. It was still far off in the distance, but kept coming closer" (Gusinde, 1975, p. 71). She summons her parents, who hear the loud roar of the waves and tell her that bad weather is on the way: "That is how it always is. When very bad weather approaches, one can first hear a dull, heavy rolling far in the distance and feel the earth trembling. And so those people said: 'Now bad weather will come and much snow will fall!' All prepared themselves. Such bad weather always comes from the east (or the southeast)" (Gusinde, 1975, p. 72). In a footnote, Gusinde confirms the truth of the weather information conveyed in this story: "bad storms almost always come from the east or southeast and announce their arrival with a loud roar. When heavy rain approaches, the splashing of the big drops from far away gives the impression of a dull murmuring. The same happens when a snowstorm lightly ripples the waves and pushes them ahead of itself" (Gusinde, 1975, p. 72).

Because forager life involves extensive intraspecific cooperation and competition, exploitation of this niche requires complex manipulations of the social as well as the physical environment. Tellingly, forager oral tradition is rife with information about human behavior – deception (Scalise Sugiyama, 2008), incest (Scalise Sugiyama, in preparation), infidelity, intrasexual competition, warfare (Scalise Sugiyama and Sugiyama, in preparation), disobedient children (Scalise Sugiyama and Sugiyama, in press), and other complications of social living. In some cases, stories simply present the consequences of the characters' actions; in others, however, these actions are judged. Indeed, oral tradition is widely viewed as "a technique of moral education, in which models of socially appropriate behavior are presented to children with praise and models of inappropriate behavior are held up to ridicule" (Fischer, 1981, p. 740). For example, "Jicarilla mythology is truly the codification of the beliefs and mores of the group. There are few matters of conduct which the Jicarilla do not refer back to this body of lore. It is thought of as the proper guide to action, positive and negative" (Opler, 1938, p. viii). Storytelling serves to enforce cultural norms as well as model them. In West Africa, for example, proverbs and folktales are used to illustrate virtuous behaviors so that children can imitate them, and scary stories are used to discourage children from engaging in proscribed behaviors (Nsamenang, 1992). For example, among the Jicarilla:

> As a means for the control of conduct there is no measure more used or more successful than the telling of a myth. If a child is unruly at night, the story of the monster owl and his basket is enough to force quiet and obedience.

> Should a boy be seen playing with an older sister or a female cross-cousin, a few pointed stories of mishaps likely to follow such thoughtlessness make him more discreet. Should a youth, angered that he has been called from play to tend horses, treat one of the animals roughly, there is a story which will cause him to think well before again allowing his bad temper to master him. (Opler, 1938, p. xii)

The claim that storytelling is used to enforce cultural norms is consonant with the observation that foragers use various forms of social sanctioning to curb antisocial behavior, ease social tensions, and prevent ill-will (Biesele, 1976; Boehm, 1993, 1999). One of the most common sanctioning tactics is criticism, which is effective because, in small-scale societies, people are highly sensitive to the disapproval of others. The indigenous tribes of Oregon are a case in point. In these groups, order was maintained "through a tradition of community approval and disapproval.... Instead of fearing a guilty conscience, a potential wrong-doer in an Indian community feared public exposure and shame above all" (Ramsey, 1977, p. xxxi). Similarly, the Dena "are very sensitive to what others may say.... the unwritten laws of the people are enforced through the strength of public opinion" (de Laguna, 1995, p. 76). Sometimes, disapproval is straightforward. In Jicarilla culture, for example, "Those who 'give' the stories to the children stand usually in a grandparental relationship to them and so it has become customary to chide aberrant conduct by inquiring scathingly of the transgressor, 'Did you have no grandparent to tell you the stories?'" (Opler, 1938, p. xii). In other cases, criticism is indirect. Among the Dena, for example, "criticisms... are never directed to the person at fault. That would be too insulting. Instead, they are mentioned to a third party, but in such a way that the person for whom they are intended can hear them" (de Laguna, 1995, p. 314). Criticism can also be rendered less confrontational through the use of humor: "In some communities, teasing by adults or peers is a way to inform people indirectly that their behavior is out of bounds or to indicate the appropriate way to act" (Rogoff, 2003, p. 217). In some cultures, this practice is institutionalized in the form of the joking relationship. For example, among the King Island Eskimo, "Cross-cousins were supposed to tease each other, to make fun of each other when somebody did something wrong.... Whenever someone misbehaved or did something foolish, someone would tell his cross-cousin about it and the cross-cousin would tease, make up jokes or songs to make the person feel funny" (Senungetuk and Tiulana, 1987, pp. 30–31). Teasing may also be used preemptively, as in the !Kung practice of "insulting the meat" to prevent hunters from becoming arrogant and domineering (Lee, 1984).

Like teasing, storytelling is a non-confrontational means of expressing disapproval: telling a pointed story in the presence of a person who has behaved inappropriately is a way of hinting that he/she needs to curtail this behavior. Stories can also be used proactively: storytelling might discourage people from transgressing by showing what will happen to them if they do so. For example, stories told by Yup'ik girls show what happens to people who engage in inappropriate behavior, such as marital infidelity

or, in the case of children, staying out after dark (de Marrais et al., 1994, p. 201). Similarly, Dena "tales instruct because they illustrate the consequences of particular actions. Repetition of the tale helps the listener to ponder the lesson therein illustrated" (de Laguna, 1995, pp. 75–76).

One of the most compelling lines of evidence that storytelling is used to broadcast and enforce cultural norms is the ubiquity and popularity of the trickster figure. Boehm (1999) identifies five behaviors that are universally proscribed in egalitarian forager societies: murder within the group, heavily self-interested verbal deception, theft, stinginess, and failure to cooperate. The trickster embodies all of these, and is widely viewed as an example of bad behavior (Scalise Sugiyama, 2008). For example, "Crow (Raven) embodies all the vices and very few of the virtues stressed by the Indians, so that while they laughed at him, even the laziest and most greedy could recognize that he was not to be emulated" (de Laguna, 1995, p. 75). Likewise, "Coyote's outrageous sexual antics, his thorough selfishness, his general irresponsibility in the stories allowed 'good citizens' of the tribe to affirm the system of norms and punishments that Coyote is forever comically running afoul of" (Ramsey, 1977, p. xxxi). As these observations illustrate, trickster stories are similar to teasing in that they use humor to sanction proscribed behavior. With stories, however, the sanctioning is more indirect: the behavior of the trickster, not a group member, is the object of ridicule. Significantly, the trickster's behavior is often discovered, outmaneuvered, and/or punished (Boas, 1898, p. 7). In this way, without accusing anyone of a crime, the group can identify a proscribed behavior, express their disapproval of it, and show potential transgressors the treatment that awaits them if they misbehave.

Greed and selfishness are not the sole prerogative of the trickster. Stinginess and free riding are widespread themes in forager folklore and are universally condemned. This attitude no doubt arises from the fact that survival in the foraging niche depends on extensively on cooperation with others: given this circumstance, benefits will accrue to individuals who are able to curb selfishness and encourage generosity in others. The vigilance with which foragers patrol this aspect of human life is seen in Klamath and Modoc myth: 88% of the myths in the Sobel and Bettles (2000) sample identified stinginess as a cause of subsistence stress, and 100% identified sharing as a means of coping with it. These stories make explicit the benefits of cooperation and the hazards of non-cooperation: sharing leads to good fortune, while theft, greed and hoarding lead to bad. For example, high-status persons (e.g., shamans, chiefs, rich men) are portrayed as reciprocators, while non-reciprocators are often punished by supernatural agents.

In sum, forager oral traditions contain information relevant to meeting a wide range of challenges in forager life. It seems unlikely that this is an accident: if information exchange increases foraging efficiency, it stands to reason that it increases efficiency in other task domains. Indeed, the ability to faithfully transmit accumulated knowledge across generations – the so-called *ratchet effect* (Tomasello, 1999; Tomasello et al., 2005) – is increasingly seen as one of the most pivotal events in human evolution. The oral traditions of foraging peoples are both a product and a record of this capacity. As

such, they constitute a vast, natural experiment: a cross-cultural record of the kinds of information people remember and share across generations in a foraging context.

Testing the hypothesis

Testing the claim that engaging in storytelling develops skills and knowledge sets that are useful later in life is a difficult proposition. This is due to the universality of the behavior in question: if all humans are exposed to storytelling, how are we to determine whether exposure to storytelling enhances knowledge or whether humans do indeed draw on information contained in stories to solve real-world problems? An ideal test would involve a withinculture comparison of performances on specific foraging tasks between two sets of individuals, one raised with storytelling and one raised without. For obvious ethical and practical reasons, such a test is untenable. However, a newspaper article about the tsunami of December 26, 2004 (Mason, 2005) suggests an alternative experimental paradigm. According to the article, only 7 of the 75,000 inhabitants of Simeulue island died, because the overwhelming majority remembered the stories their grandparents had told them about the "semong" (tsunami) of 1907 and fled to higher ground. As one informant reported, "After the earthquake, I looked for the water to suck out.... I remember the story of the 'semong' and I ran to the hill." A test similar to this natural experiment can be envisioned in which performance on a given task is compared between subjects who are told a story that contains information useful to performing the task and subjects given the equivalent information in non-narrative form (or who are told a story unrelated to the performance of the task). Neuroimaging provides another means of testing the hypothesis that storytelling is used to acquire information instrumental to constructing future scenarios. Are the brain regions activated by planning tasks also activated during narrative processing? Are the same brain regions activated by episodic memory tasks also activated during narrative processing?

We can also make predictions about cross-cultural patterns in story content. As the tsunami article suggests, we would expect stories to contain information about phenomena that occur at intervals longer than the human lifespan (e.g., calamitous earthquakes/ tsunamis, severe droughts, 100-year floods). Another prediction is that stories should contain information that is difficult or dangerous to acquire at first hand – for example, information regarding environmental hazards (e.g., toxic substances, dangerous animals, getting lost, inclement weather). On this point, Bock and Johnson (2004) argue that play is an important means of learning when there are constraints on learning through first-hand experience. Conversely, because some skills (e.g., shooting an arrow, cracking nuts, weaving a basket) are best acquired through observation and practice, we would not expect stories to contain detailed explanations of how do these things. However, we might expect them to contain information relevant to locating, selecting, and/or processing materials used in these tasks.

To test the hypothesis that parents invest knowledge in their offspring via storytelling, the most critical and obvious data needed is information on who tells stories to whom. Although studies of daily life skill transmission sometimes include "non-practical" skills such as dance, pottery decoration, and bead making (Hewlett and Cavalli-Sforza, 1986; Shennan and Steele, 1999), they do not include storytelling. Anecdotal observations in the ethnographic and folklore literature indicate that folklore and mythology are transmitted vertically, but the degree to which this transmission is from parent (or alloparent) to child is unknown.

Another important avenue of inquiry is the age at which children become "accomplished naturalists." If it is true that "the years between the five-to-seven shift and puberty are a human adaptation for a large amount of cultural acquisition" (Konner, 2010, p. 637), we would expect older children to be more knowledgeable than younger children. This could be tested by administering a questionnaire to different age groups to measure proficiency in various knowledge sets (e.g., animal behavior, spatial and temporal distribution of resources). Data could also be collected on the age at which children begin foraging for various resources, then compared with foraging knowledge data to see whether (and how much) knowledge acquisition occurs before children begin foraging on their own. These data would provide a basis for estimating how much knowledge is acquired through social learning. Finally, if it is true that stories are an important source of knowledge in forager cultures, then another knowledge set foragers must master is the oral tradition itself. Anecdotal evidence suggests that this knowledge is not mastered until relatively late in life. Among the !Kung, for example, young and even middle-aged storytellers are rare, and it is "the addition of knowledge, not secret knowledge but a large collection of items which takes a long time to accumulate, which results in competent storytelling. It is generally the case that by the time a person is a *zhu n!a* ('old person') he will have accumulated a good deal of this knowledge" (Biesele, 1976, p. 308). Quantitative data on how many different stories each group member knows is lacking, but would not be prohibitively difficult to collect.

Discussion

In arguing that storytelling is a means of social learning, I am not arguing that storytelling is the *only* means of social learning. Rather, storytelling is one of several means by which humans invest in cognitive capital. Nor am I arguing that every information byte in a given story is useful information. Rather, my claim is that forager oral tradition includes information that is potentially useful in solving problems recurrently encountered in forager life. Whether a given piece of information proves to be useful will vary from individual to individual, depending on his/her attributes, constraints, and the events that befall him/her.

If prolonged juvenility evolved, in part, to support learning, then humans may have been under selection to invest in cognitive capital. A case in point is the enjoyment

humans get out of listening to stories, which may be rooted in an evolved interest in acquiring information beyond what is immediately necessary. Such an interest has been documented for animal behavior: for example, !Kung men "sometimes observe animals more than is necessary for the purpose of the hunt in which they are involved" (Blurton Jones and Konner, 1976, pp. 337–338; see also Nelson, 1969). This seemingly superfluous interest is hypothesized to be a risk-buffering strategy – a means of acquiring knowledge about animal behavior that might be useful in the future (Blurton Jones and Konner, 1976; Mithen, 1990). On this logic, we would expect humans to have an evolved interest in acquiring information useful not only for hunting, but for gathering, wayfinding, mating, parenting – in short, any evolutionarily recurrent task with inherent risks that can be buffered by knowledge. Humans may find stories interesting because they simulate the whole of human experience – human beings, their actions, and environmental constraints on those actions – and therefore present information concerning a variety of task domains.

As noted above, information exchange "and the effects of incomplete information are important issues particularly relevant to human foragers, who rely extensively on learning and communication to assess resource distribution, abundance, and profitability" (Kaplan and Hill, 1992, p. 186). If information is so critical to success in the foraging niche, we would expect foragers to exhibit concern regarding its reliability. This appears to be the case. The !Kung, for example, distinguish between directly observed behavior, behavior deduced from tracks, hearsay (behavior reported by another person), and behavior they think could happen, and are hesitant to accept as fact behavior they have not witnessed themselves (Blurton Jones and Konner, 1976). This attitude is widespread in oral cultures (Rogoff, 2003, p. 40), and is evinced in storytelling as well. For example,

> Athabaskan languages allow, or rather necessitate, that the narrator indicate how they learned what they are telling: for example, there is a form that indicates that the statement is based on personal experience; another form if it was deduced, as one would deduce the movement of an animal from its tracks; and lastly, "they say" or "it is said," indicating that one is repeating hearsay. (de Laguna, 1995, p. 291)

Across forager oral tradition, a common refrain is a statement to the effect that the narrator has seen the object or event in question. For example, in an Apache variant of the running rocks tale, the informant asserts: "Those rocks are over near Taos still. There is a black mark on them even now where Coyote defecated on them.... The story says they are tied together, but when I saw them they were joined together" (Opler, 1938, p. 336). Similarly, a Yanomamö storyteller claims, "I have seen it [the Kaithë u River] with my own eyes, at the source of the Hwara u, in that direction. The old people with whom I was traveling in the highlands showed it to me and said: 'There's the Kaithë u! That's the river that Omamë caused to burst forth by piercing the ground!'" (Wilbert and Simoneau, 1990, p. 406).

This attention to the source of information is paralleled by an interest in keeping story content consistent across time and space. Among the Klamath and Modoc, for example, only adults were allowed to narrate myths, and if a narrator deviated from the standard text, listeners could interrupt and debate until the correct version was decided upon. For this purpose, the Klamath preferred that two individuals well-versed in the myth were present to prevent transmission errors on the part of the narrator (Sobel and Bettles, 2000). Among the Dene, "repetition of the tale by the same author serves to fix it in the memory of the listeners, and... the ability of the young people to repeat the story accurately, and honestly (without help or hints), would be tested later by their elders" (de Laguna, 1995, pp. 74–75). These measures are what we would expect if oral tradition were a means of storing and transmitting valuable information – that is, if humans' "most effective technology... is one that can be carried around in their minds" (Ridington, 1988, p. 73).

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