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II

Why Does Childhood Exist?

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II

Why Childhood?

Nick Blurton Jones

Compared to their closest relatives, people have an elongated juvenile period, beginning to reproduce at a greater age than other great apes (hominoids). The difference has been noted, and explanations offered since before the beginning of anthropology. Most prominent, and oldest among these explanations has been the observation that forager subsistence involves many learned skills and extensive knowledge, and the idea that the juvenile period must be extended to allow these skills to be acquired before adulthood. Other ideas about extended juvenile periods have been offered in recent years, for example, that juveniles can avoid risks by growing more slowly (and thus perhaps for longer; Janson and van Schaik 1993), that a new phase, "childhood," has been inserted into the life history, thus elongating the time to first reproduction (Bogin 1988, 1999), and so on. (Several of these alternatives are outlined and discussed in relation to the comparative and fossil evidence in Paine and Hawkes, in preparation.)

Meanwhile, biologists who study life histories have established a very general relationship between the length of the juvenile period (weaning to first reproduction) and the length of the adult lifespan (e.g., Charnov 1993). Within major taxa these bear a constant relationship to each other. This arises because age at first reproduction is a result of a compromise between the benefits of growing to a larger size (which takes longer) and the costs of a shorter time in which to recoup these benefits (more time spent growing means less time reproducing). The governing factor appears to be external influences on adult mortality rates. If mortality increases, there will be less time to recoup the benefits of growing for longer and it will pay to begin reproducing earlier. If mortality decreases, there will be more time to reproduce and it will pay to take a little more time and grow larger. Alvarez (2000) has shown that humans fit closely with the relationship between juvenile period and adult mortality (and several associated measures).

Thus there is now an alternative view of the length of the human juvenile period: that there is nothing to explain about the juvenile period, so long as we can account for the longer adult lifespan. In an ecology where highly productive foods exist but are too difficult for juveniles to acquire, then juveniles must be provisioned. This opens an opportunity for older helpers to enhance their fitness by acquiring food that they transfer to younger relatives. This could select for prolonged vigor in the older individuals. While, in this context, Hawkes et al. (1989, 1998) have attended primarily to women (grandmothers), others such as Marlowe (2000a) and Kaplan et al. (2000b) have emphasized the role of men. Chapters on older men and women as helpers of mothers and children are presented in Part III.

The studies represented in the current section address the contrasting ideas about the role of learning in the evolution of a longer juvenile period by examining details of the behavior of children, especially their subsistence behavior.

Bock supports a view close to that outlined by Kaplan et al. (2000b). These authors do not espouse the early idea that everything must be learned before maturity. They suggest that theories such as Charnov's should consider not merely physical growth, but any investment in "embodied capital" such as skill and knowledge that will affect later reproductive success, and in the body's maintenance mechanisms that affect mortality. They suggest that where skill and knowledge play a large role in subsistence, selection will favor a longer juvenile period (it will pay to spend more time learning, even if individuals continue to learn after maturity) together with greater investment in brain and in the body's maintenance functions. They propose that long life, encephalization, and a later age at maturity should evolve together. They suggest that hunting is the part of human subsistence that most strongly favored these changes. It becomes important to show the dependence of subsistence skills, and especially hunting or its component skills, upon experience. Bock has documented the age changes in various important subsistence skills among children on the Okavango Delta, and investigates the extent to which increases with age reflect skill, or merely strength. He took a variety of measures of strength. Seeking to understand the interaction of strength and experience has led to his proposal of a "punctuated development model" to encompass the interaction of strength and skill in shaping the sequence and age patterning of skills and learning.

Bird and Bliege Bird are also involved in trying to discriminate effects of size and strength from learning. They ask whether Mardu children are really such inept foragers and slow learners, and find that they actually forage in the best patch for individuals who are short and walk more slowly than adults. This finding resembles their earlier reports on Merriam children (Bird and Bliege Bird 2000, 2002; Bliege Bird and Bird 2002b), who select an optimal set of prey for people of their walking speed, they are optimal foragers on littoral fauna. Tucker looks at foraging by Mikea children and points out that we often underestimate the efficiency of child foragers because they have other things on their minds—playing, staying out of the sun, watching passers by, and so on. These studies add to recent evidence that the traditional "needing to learn it all before you can reproduce" idea is inadequate. Children learn many things but learn them very rapidly. In some foraging skills they match adults from an early age [Bird and Bliege Bird (2002) found that Merriam children were better spear-fishers than most adults]. Losing "bush experience" in boarding school did not impair foraging skills among Hadza children (Blurton Jones and Marlowe 2002). !Kung do not begin to learn to hunt until they are 20 or so (Nancy Howell, personal communication, 2002), and Walker et al. (2002) show that Ache hunting success increases during the adult years, as it also does among Hadza (Marlowe 2000a; Blurton Jones and Marlowe 2002). These findings contradict the earliest ideas about subsistence learning and the juvenile period, that learning is not all accomplished before adulthood. Most Ache and Hadza men are married with children long before they reach their peak hunting efficiency. Foraging must be learned but it is learned as a juvenile and as an adult and seems to have little direct relationship to the age at which reproduction begins. While researchers in this field currently think of themselves as supporting opposed theories about evolution of the juvenile period, they all agree that more data collection and more modeling are needed. We might also do well to bear in mind that the differences between humans and our closest relatives might not have all arisen together in a single evolutionary step.

So far I have only discussed the length of the juvenile period, using the biologists' definition: weaning to first reproduction. The chapters in this section use childhood and juvenile interchangeably, for anyone who is no longer an infant (weaned) and not yet an adult (bearing children). But other authors have divided this period into varying numbers of pieces. Among these authors Bogin (1988, 1999) has made the most effort to relate his concepts to the primate and animal literature. Paine and Hawkes (in preparation) report a seminar on evolution of human life history in which, among other things, it became clear that Bogin's concept of childhood was valuable, not in its concept of "insertion" elongating the juvenile period but in its pointing to a disconnection between weaning and other measures such as eruption of the first permanent molar tooth (M1). While these tend to coincide in other primates, weaning is very early in humans (even foragers) when compared to other hominoids and long precedes events such as eruption of M1. Bogin's concept of childhood covers the period from weaning to eruption of M1 and he notes that the end of this period coincides with the "5-7 year old shift" often written about by developmental psychologists. These concepts have played no part in recent studies of young hunter-gatherers (such as the detailed studies of parent-child interaction reported in Parts III and IV). But perhaps they should.

Tucker's discussion of the playful nature of Mikea children's foraging raises another issue, which receives more attention in Chapter 16 by Kamei. Play is probably a way in which children make a start on learning many things. Bock (1995, 2002a) has shown how parents trade off the value of children's productive work against the imputed future value of their play. Bock suggests a way in which theory might be used to predict how much time children (and/or parents) allocate to different activities. So far, his suggestions have not been followed up by other researchers.

In closely knit forager societies it is also possible that both children's play and their productive work affect the attitudes others have toward them: they begin to gain reputations for being lazy or hard-working, skillful or clumsy, helpful or uncooperative, domineering or a pushover, and so on. An individual's reputation may affect how others treat him or her and this may have important and lasting effects on their adult lives. This may be true in any society but in a species that has such good recognition of individuals and such good ways of communicating attitudes, and in societies that have few members and tend to live with a limited subset of those members throughout their lives, such early formed reputations may be especially powerful.

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5

What Makes a Competent Adult Forager?

John Bock

INTRODUCTION

In this chapter I examine the ways in which experience-based embodied capital, operationalized as skill, and growth-based embodied capital, operationalized as strength, interact to produce age-specific competency at different foraging activities among children in a multiethnic community in the Okavango Delta of Botswana. The chapter begins with a presentation of alternative theories of the evolution of childhood, and proceeds to a brief review of several recent studies that have tested hypotheses derived from these alternative theories through examining children's activities in traditional societies. Next I introduce the study community and describe the data collection and analysis methods. I then present the results of the study, which are followed by a discussion of these results including their implications for our understanding of the effects of growth- and experience-based embodied capital on the development of foraging competency in this community and broader implications for theoretical development and future research.

MODELS OF THE EVOLUTION OF CHILDHOOD

The lifeway of hunting and gathering characterizes the context of human evolution. The initial foray into alternative subsistence ecologies involving the production of food, such as farming, occurred only about ten thousand years ago, at least 90 thousand years after anatomically modern humans emerged (Binford 1968; Lee and Devore 1968; Washburn and Lancaster 1968; Lancaster and Lancaster 1987). Since that time, most human populations have shifted their dependence from hunting and gathering to agricultural food production (Bender 1975). For many populations the transition has occurred within the last millennium and is not yet complete (Johnson and Earle 1987). This means that the human life history pattern-the timing of and allocation of resources to critical life events such as growth, maturation, reproduction, and mortality-likely evolved in the context of a hunting and gathering lifestyle (Hill and Hurtado 1996; Kaplan et al. 2000a; Hawkes et al. 1998). Childhood is an aspect of human life history that differs from that of the other apes in the duration and the degree to which offspring are dependent on parents or others for provisioning. Recent theoretical debate has centered on whether these differences are due to features of the hunter-gatherer subsistence ecology in which humans evolved (Bock 1995; Kaplan et al. 2000a; Bock and Sellen 2002a; Bock 2002a; Bogin 1999) or are due to other selective forces such as the low rate of extrinsic mortality of primates in general (Charnov and Berrigan 1993; Blurton Jones et al. 1999; Blurton Jones and Marlowe 2002; Bird and Bliege Bird 2002; Bliege Bird and Bird 2002; Bird and Bliege Bird, Chapter 6 in this volume).

Three life history models have been recently used to understand the slow growth and extended juvenility of humans (Leigh 2001): the brain growth model (Bogin 1999); the adult mortality model (Charnov and Berrigan 1993); and the embodied capital model (Kaplan et al. 1995, 2000a; Kaplan 1996; Kaplan and Bock 2001). The brain growth and embodied capital models both focus on learning as a powerful selective force on the juvenile period in humans and see the large human brain and the long juvenile period as a response to the great amount of learning-based knowledge necessary to be a competent forager. In these models, slow growth provides the time needed to fully program the brain with the environmental knowledge, requisite technical skills, and social aptitude to effectively extract resources from the environment. The models differ, however, in that the embodied capital model provides a framework in which the costs of slow growth are distributed across generations. This leads to different predictions between these two models regarding growth rates through the life course. The brain growth model predicts rapid early growth but does not address continued growth of the rest of the body after the brain has stopped growing, while the embodied capital model predicts both early growth and variation in later growth (Leigh 2001).

The adult mortality model developed by Charnov (1993) and extended to humans by Blurton Jones, Hawkes, and colleagues (1999) argues that organisms shift investment at some point from their own growth into producing offspring. According to this model, the human juvenile period is not different from the other apes adjusted for lifespan. We have a long juvenile period simply because we are unusually long-lived (Alvarez 2000). In this case, natural selection is not directly acting to extend juvenility but is rather a consequence of slow growth. Knowledge and skills acquired during the juvenile period are beneficial according to this model, but those benefits are not sufficient selective pressure to have extended the juvenile period. Leigh (2001) states that the adult mortality model accurately predicts extension of ontogenetic phases but does not generate predictions consistent with the variation in growth rates seen in humans.

EMPIRICAL STUDIES

These models place differing emphasis on the selective impact of learning on the evolution of childhood. Recent empirical studies have focused on the effect of skills acquired through experiences, such as social learning, on children's competence in tasks related to food procurement (Bock and Sellen 2002b). Bliege Bird and Bird (2002a, 2002b) found that Meriam children in Australia were far more constrained in their marine foraging returns by body size than by experience-based skill. In this study, however, the technology needed to forage was not a factor in variation in costs associated with differences between adult and children foraging. In a review of ethnographic data from twelve traditional societies, Shennan and Steele (1999) conclude that the acquisition of craft-making skills occurs largely through vertical transmission from same-sex parent to child and requires most or all of childhood to acquire. In addition, they argue that this transmission of craft-making skills is a form of parental investment. In their study of Aka foragers, Hewlett and Cavalli-Sforza (1986) also show that the acquisition of most food procurement skills is the result of vertical transmission, and that most skills are acquired by age ten. Clearly, in situations where there is reliance on technology for food procurement, inclusion of the costs of producing that technology makes it unlikely that children will be net producers of food resources. Moreover, recognition of the costs of technology production indicate that provisioning of technology to offspring by parents is a form of parental investment that increases either the rate of energy capture or skill acquisition by offspring, or both. Several studies have found that among nomadic hunter-gatherers, parents spend far less time with their children after sedentization and the initiation of farming (Ju/'hoansi: Draper and Cashden 1988; Ache: Hill and Hurtado 1996), suggesting that the benefits of vertical transmission, and therefore parental time investment, may be less in non-hunter-gatherer subsistence ecologies. Overall, the results have not been conclusive, and appear to be strongly related to the complexity of tasks intrinsic to a given local subsistence ecology as well as to the nature of precursor and sequential tasks.

One potential confound is the tasks examined. In their study of Hadza adolescent skill development, Blurton Jones and Marlowe (2002) argue that both school attendees and non-school attendees have similar skill levels. They found, for instance, that there was no difference in bow and arrow shooting accuracy. This is only one component of a complex task in the actual process of food procurement that includes technology production, locating and tracking prey, stealthy lying in wait or stealthy pursuit of prey, and accurately delivering a projectile to a potentially moving target. [See Liebenberg (1990) for a thorough description of the component tasks involved in hunting with traditional weaponry on the African savanna.] Even if there is no difference in bow and arrow shooting accuracy between school attendees and nonattendees, this does not mean that they are equally able to accomplish all of the tasks that are precursors to actually shooting an arrow at an animal, or turning a wounded animal into food.

Other studies have found that experience has strong effects on task performance related to food procurement. Ohtsuka (1989) found that age had a significant effect on the hunting ability of Gidra Papuan men, controlling for strength and body size. Walker et al. (2002) found strong age-effects among Ache foragers in male ability to locate potential prey. Controlling for measures of strength and body size, older men had significantly higher encounter rates. This is corroborated to some extent by several studies in conservation biology that demonstrate significantly higher encounter rates by indigenous foragers compared to professional biologists (Hill et al. 1997; Stander et al. 1997). Bock (1995, 2002a) showed that among the Okavango Delta peoples of Botswana, there was a significant effect of age on mongongo nut processing returns among women. These studies, however, focus on complex and difficult tasks, often depending on the production and use of technology as well as the successful sequential performance of many subcomponents. It is clear from these studies that a more holistic approach that analyzes the relationship between growth and experience in a given ecological context is critical before we can completely distinguish the effects of experience and growth on performance in foraging-related tasks.

THE PUNCTUATED DEVELOPMENT MODEL

Kaplan and associates (Kaplan et al. 1995; Kaplan 1996; Kaplan et al. 2000a; Kaplan and Bock 2001) have proposed a theory of human life history evolution based on returns to investment in embodied capital. This theory integrates human capital theory in economics with life history theory from evolutionary biology by treating the processes of growth, development, and maintenance as somatic investments. Investment in embodied capital has two aspects, the physical and functional. The physical payoff to in-

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vestment in embodied capital is the actual tissue involved. The functional payoff to investment in embodied capital is manifested in qualities such as strength, immune function, coordination, skill, knowledge, and other abilities, which are based in organized somatic tissue (for a complete treatment, see Kaplan et al. 2000a). The total of both the physical and functional aspects of embodied capital can be viewed in relation to the capacity to be a competent adult. Building on the embodied capital model, the punctuated development model was created as a theoretical framework to understand the effects of experience and growth on task performance within the context of a local ecology (Bock 2002a).

GROWTH-BASED AND EXPERIENCE-BASED EMBODIED CAPITAL

We can further distinguish embodied capital into growth-based forms and experience-based forms (Bock 2002a). Growth-based forms of embodied capital are attributes like body size, strength, balance, and general coordination. Experience-based forms of embodied capital are attributes such as cognitive function, memory function, task-specific skills, learned knowledge, endurance, and specific coordination. Growth-based forms tend to be more related to general competency, while experience-based forms tend to be more related to specific competency. The ability to perform any task is comprised of a suite of both growth-based and experience-based embodied capital. Depending on the physical demands and complexity of the task, we can imagine the gamut from those heavily weighted toward growth-based embodied capital to those nearly entirely dependent on experience-based embodied capital, with many tasks requiring hefty portions of both.

This model assumes that complex tasks involve thresholds of ability that must be reached before we can consider someone able to perform a given task. It is possible for a person to have one or two of the necessary forms of embodied capital but still be unable to perform a task. One must achieve a certain level at each of these components before the threshold of ability is crossed. Even after one is able to perform the task at a rudimentary level, depending on the difficulty of the task there may be considerable opportunity for improvement.

PARENTAL INVESTMENT AND LEARNING

This model can be used to frame the effects of paternal investment of time and resources on child outcome in terms of different forms of embodied

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capital. In different subsistence ecologies and for different tasks, the investment in growth needed to bring a return in learning varies (Bock 2002a; Bock and Johnson 2002b). As growth-based embodied capital constrains the payoff to investment in experience-based embodied capital there will be diminishing returns to investment in learning. The degree to which growth constrains learning will vary as a function not only of subsistence ecology but also of the economics of production (Bock and Johnson 2002b). It may also be strongly influenced by the value of labor and the opportunity cost to alternative activities (Bock 2002b). In foraging economies as in all others, the variety of tasks performed can be expected to reflect a number of different levels of growth constraints on payoffs to learning. Investment of resources and time by parents in their offspring can be used to build growth-based embodied capital or it can be used to develop experience-based embodied capital. The optimal solution is expected to ultimately depend on the reproductive interests of parents, which is also subject to the societal based gender- and age-patterning of production, and on the specific labor needs of the household.

When a parent is faced with these allocation decisions across a number of offspring determining the optimal solution quickly becomes a complicated endeavor. In one-child families, assessing the costs and benefits of investment in different forms of embodied capital is relatively clear-cut from a theoretical standpoint. With each additional child, this assessment becomes more complex with the addition of opportunity costs and multiple time frames. A parent's reproductive interests are unlikely to coincide with those of any one of their children (Blurton Jones 1993; Bock 1995, 1999, 2002a, 2002b; Worthman 1999). Rather an evolutionary perspective leads us to believe that parents should be concerned that their reproductive interests are manifest in all of their children. They should even be willing to act to the detriment of a child if doing so benefits the parents themselves. Such conflicts are rife when investment in one child affects investment in others (Trivers 1972a).

THE STUDY COMMUNITY

These issues are examined using data collected in a multiethnic community of approximately four hundred people in the Okavango Delta of northwestern Botswana (Bock 1995, 1998; Bock and Johnson 2002a, 2002b). Five ethnic groups are represented, including two San-speaking groups, the Bugakhwe and the ||Anikhwe, and three Bantu groups, the Hambukushu, the Dxeriku, and the Wayeyi. ||Anikhwe and Bugakhwe people inhabit the Okavango drainage in Namibia and Botswana, with ||Anikhwe historically having a riverine orientation in their foraging, while Bugakhwe have been savanna foragers. The ||Anikhwe living in the study community currently practice a mixed economy, but farm at a much less intensive level than the Bantu groups in the area. All ||Anikhwe families acquire the bulk of their resources from foraged foods. Among 50 ||Anikhwe there were only four head of cattle, compared to a typical Bantu homestead of 20 people with 12 head. Bugakhwe in this community are largely oriented toward fishing, hunting, and the collection of wild plant foods. None own cattle, and a few have small gardens where they grow tobacco and specialty foods such as vegetables.

Hambukushu, Dxeriku, and Wayeyi people inhabit the Okavango River drainage from Angola through the Caprivi Strip of Namibia into northern Botswana. Historically, they have participated in mixed economies of farming, foraging, and pastoralism.

People from all of the ethnic groups live in extended family homesteads based on patrilocal organization. Among the Bantus, polygyny is common, with 45 percent of the men over 35 participating in polygynous relationships at any one time. Polygyny is rare among the San speakers but marriage and reproductive unions are fluid among all the ethnic groups. Multipartnered sexuality is commonplace, and disputes over paternity and child support are common in the tribal court. For all the ethnic groups most men marry and become fathers in their thirties.

At the time of the study, this community was fairly isolated. There was very little cash economy in the study community, so most men of all ethnic groups over the age of 35 had worked in migratory labor, usually in the mines of South Africa, for an average of five years. Many of the ||Anikhwe and Bugakhwe men over the age of 25 had been soldiers in the South African Defence Force during the bush wars of the 1970s and 1980s. Few women, however, had ventured beyond the next community, 30 kilometers away. There was no school or clinic, or borehole, so water was drawn from a river source. The nearest primary school was in the next community, and children attending that school needed to board while attending school. While there are no school fees in Botswana, the cost of boarding, uniforms, and books as well as the lost labor made school costly to parents. At any one time, approximately 25 percent of the children in the community attended primary or secondary school. Those attending secondary school boarded at communities at least one hundred kilometers away. Due to the lack of vehicles and roads, children attending school returned home only sporadically.

Historically, the Bantus represented in this community have all had some degree of matrilineality in their social organization with a tradition of the avunculate (Larson 1970). In earlier times a boy's strongest male influence would not be from his father but from his mother's eldest brother. Both ||Anikhwe and Bugakhwe were strongly influenced by Bantus over at least the last one hundred years and also have some degree of matrilineality and the avunculate. The situation is not clear-cut, however, since all ethnic groups in the study community have been under strong political and social influence of Tswana-speaking tribes for at least two hundred years. The Tswana have a strong tradition of patrilineality in their social organization and customs regarding marriage, the family, and childrearing, which have been codified as Botswana's Customary Law. All disputes are settled using this legal code regardless of the ethnic origin of the litigants, and this has had a profound impact on the maintenance of social organization and tradition by non-Tswana groups.

Fieldwork in this community began in 1992 as part of a dissertation project focusing on the determinants of children's activities. There was an additional field session in this community covering most of 1994, and there have been frequent subsequent visits, with the latest in 2001. A second community composed mostly of ||Anikhwe and Wayeyi families that was far more market incorporated was included in the study beginning in 1996, with two years of data collection ending in 1997.

METHODS

In this analysis, two types of data are used: strength measurements and tests of performance ability.

The "Field Days"

Anthropometric measurements and tests of general performance ability were collected from 54 girls and 74 boys on August 28, August 29, and October 8, 1994. The first two dates comprised a weekend and both children who attend school away from the community and those who do not were included. The third date was a "makeup" date that allowed us to measure any child not previously tested. The tests of general performance ability included throwing for distance, running, and a test of arm strength using a 25 kilogram spring balance. Each test was set up as a station, and the children were rotated through the stations in the same order. These test days were organized along the lines of a field day. The community was divided into three parts. Shortly after dawn, three researchers equipped with a list of children three to 18 years old from each homestead ventured into a different part of the community, visiting homesteads and meeting with the most senior person available. Researchers asked permission to test the children in that homestead in a series of throwing, running, and carrying tests as well as permission to measure the height and weight of the children. Permission was invariably granted. The children were then called together and

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told to proceed to the researchers' house at a certain time indicated by the position of the sun. These times were staggered to facilitate data collection.

At the end of the first two days, we noted which children were absent. The following test day, special effort was made to impress upon those children and responsible adult caretakers that the participation of all children would be of great help to the researchers. At the completion of testing children were provided with soft drinks, popcorn, and other snacks, and as always, were allowed to use any recreational equipment they desired such as soccer balls, frisbees, and ball and bat.

Measuring Growth-Based Embodied Capital

Arm pull strength was obtained in order to estimate the effect of strength on task performance. A 25 or 50 kilogram Homs hanging spring balance was attached to a tree trunk. Each participant would then sit cross-legged in the sand at such a distance from the tree that the person's arm was fully extended when grabbing the hook on the balance, but not so that he or she needed to lean forward. A researcher sat or squatted behind the person so that his or her back remained perpendicular to the ground during the test. The participant was instructed to grab the hook with whichever arm was stronger and to pull the hook toward him or her using only the arm, not the back, shoulders, or legs. If a person was using these other body parts, the test was begun again after further instruction. A researcher watched the scale on the spring balance to determine the maximum value that the individual could sustain, rather than a peak value resulting from a quick pull or jerk on the hook. This value was recorded to the nearest kilogram.

Measuring Skill in Mongongo Nut Processing

Mongongo nut processing return rate experiments were conducted with children and adults of both sexes between January and November 1994. For these experiments, a sack of mongongo nuts was bartered in return for transporting a group to a mongongo tree patch. A woman was then enlisted to perform the first stage of processing, leaving the nuts with their outer shell exposed ready to process. For the processing rate experiment, an individual was given five hundred grams of whole nuts in the outer shell. These were also counted. The individual was instructed to process them as if he or she were at home, and the digital timer started. After fifteen minutes the individual was told to stop and the number of nuts processed was counted. The remaining nuts were weighed, as were the product. In addition, the number of intact inner-shelled nuts was counted, and it is this quantity that is used in the analysis.

Measures of Fishing Skill for Both Males and Females

Fishing return rates were collected throughout both planned and opportunistic observation of children between 3 and 18 years old during the period from January to November 1994. Focal follows of individuals were undertaken twelve times a week. Homesteads were sampled on a rotating basis, as were children within homesteads. The follows lasted two hours, and consisted of point samples every ten minutes. At the point sample, the activity in which the child was engaged, the location, and identity of coparticipants was recorded. In addition, the time of any resource acquisition was noted, as well as the type, amount of resource, and method of acquisition. Weights were obtained using Homs hanging spring balances. A second type of data collection regarding the fishing return rates was opportunistic in nature. Most fishing activity either took place or originated at a beach on the central lagoon. In addition, fishing had a periodicity with respect to the time of day. Most fishing took place from midmorning to midafternoon. On selected days this area was visited prior to the usual start of fishing. All children were offered a hook and a length of line, including children who would usually be considered too young to fish. The start and stop times of fishing, the location of the fishing, the time of any resource acquisition, and the weight of each fish caught were recorded for each child until all children had ceased fishing.

Four types of fishing by children were observed: hook and line from shore, hook and line from a dugout canoe, basin, and basket. There is a gender difference with respect to these methods. Hook and line fishing from a boat is nearly exclusively a male activity. Very young boys, some girls, and some older boys who cannot find a boat at the time they wish to fish will do hook and line fishing from shore. Basin and basket fishing are exclusively female activities with basin fishing being done by extremely young girls.

Operationalization of the Variables and Data Analysis

Because experience- and growth-based embodied capital both encompass a number of individual characteristics, they can be operationalized in a number of ways. Arm strength as collected in this study is a measure of growth-based embodied capital and is an indicator of body size, musculoskeletal maturation, and—to a lesser extent—general coordination. Arm strength is a particularly appropriate measure of growth-based embodied capital in this analysis since both mongongo nut processing and fishing rely on movement and manipulation of technology via the arms. The extent to which this usage affects competence in resource acquisition will be reflected in the contribution of arm strength to variation in return rates for a given resource as determined by regression analysis.

Age covaries with many measures of growth and maturation. For instance, In this population age accounted for 92 percent of the variation in height and 94 percent of the variation in weight (Bock 1995). We can also expect that if there are benefits to skill gained from experiences such as social learning, the more experiences one has the greater the skill level embodied within that individual. Since experiences accumulate with age, we should also expect age to covary strongly with experience-based embodied capital. To isolate the component of experience-based embodied capital related to age, multiple regression was used. In this way, growth-based embodied capital measured as strength can be controlled for and the partial effects of experience-based embodied capital on competence can be assessed.

For the three tasks, mongongo nut processing by females, basket fishing by females, and canoe fishing by males, multiple regressions of return rate on age and arm strength for all tasks are presented in Tables 5.1 through 5.5, showing the partial influence of experience- and growth-based embodied capital on competency. In addition, the bivariate relationship between significant predictors and returns are presented as OLS regressions. These graphical formats help to visualize the relationships, but do not isolate the partial effects of experience- and growth-based embodied capital on task performance.

RESULTS

The results begin with an examination of the effects of growth- and experience-based embodied capital on mongongo nut processing. They continue with an analysis of girls' fishing using baskets from shore, and conclude with an examination of boys' fishing using hook and line from canoes.

Mongongo Nut Processing

Multiple regression analysis shows both that age has a significant positive effect and that age-squared has a significant negative effect on mongongo nut processing competence, consistent with the bivariate model (see Table 5.1). The multiple regression also shows, however, that strength as a measure of growth-based embodied capital does not have a significant effect on mongongo nut processing ability when age is controlled for.

Mongongo nut processing has a distinctive inverted U-shaped relationship of age and processing ability (see Figure 5.1). Ability increases through the teens and twenties and peaks in the mid-thirties to mid-forties, then begins a steady decline. This is similar in shape to age-specific return rates for

Table 5.1 Multiple Regression of Mongongo Processing Returns on Age and Arm Strength for Females of All Ages[a]

Model	*Unstandardized Coefficients* B	*Std. Error*	*Standardized Coefficients* *Beta*	t	*Sig.*
Full (constant)	–17.960	10.303		–1.743	.012
Age	3.212	0.639	4.621	5.022	.001
Age squared	–0.037	0.007	–4.542	–4.936	.001
Arm strength	–0.248	0.298	–0.305	–0.830	.431

[a] $n = 20$. Age has a significant positive effect while age squared has a significant negative effect while controlling for arm strength.

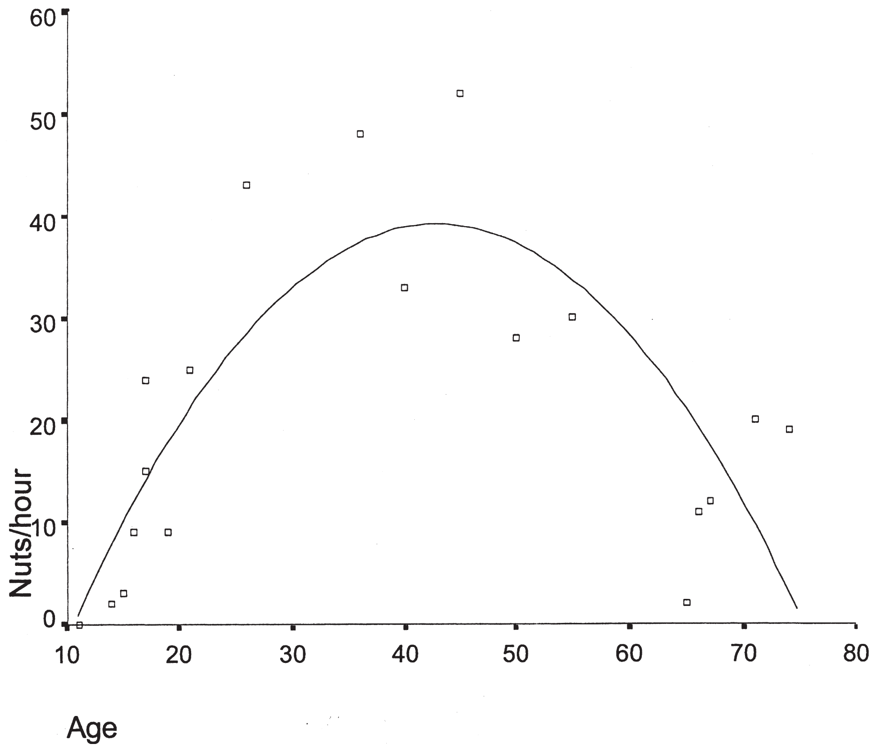

Figure 5.1. Age-specific mongongo nut processing returns for females of all ages. Each point represents the number of nuts successfully processed in 15 minutes. A polynomial regression fit to these data shows a significant effect of age that is positive at earlier ages and negative at later ages. $n = 20$, $p^2 = 0.6119$.

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other foraging activities such as hunting (Kaplan et al. 2000a). The continued increases to the return rate after growth stops in the early twenties suggests that growth-based embodied capital is not the primary influence on mongongo nut processing competence.

Basket Fishing by Girls

Multiple regression analysis of the effects of age and arm strength on girls' basket fishing returns shows that when controlling for age, the influence of arm strength becomes nonsignificant (see Table 5.2). This indicates that there is no additional significant effect of arm strength and that variation in girls' basket fishing returns is due to the effects of age alone.

This can be seen graphically in the univariate regression analysis of return rate on age (see Figure 5.2) among girls.

While experience-based embodied capital is a major influence on girls' basket fishing return rates measured as kilocalories/hour, a different relationship emerges when examining the mean weight of fish caught. Multiple regression of return rates on age and arm strength shows that arm strength is a significant predictor of mean weight while age is not (see Table 5.3). This indicates that different attributes are important in the development of competence in locating fish and in landing larger fish. Experience may be important in knowing where to find fish, but to catch larger fish requires a larger basket and the strength to move the basket through deep water.

Canoe Fishing by Boys

Multiple regression analysis shows that age does not significantly affect return rate for boys' fishing, but that arm strength has significant positive effects (see Table 5.4). This indicates that for boys' fishing, in contrast to girls' fishing, growth-based embodied capital is a major determinant of competence.

Table 5.2 Multiple Regression of Mean Return Rate for Basket Fishing on Age and Arm Strength for Girls 3–18 Years Old[a]

Model	*Unstandardized Coefficients* B	*Std. Error*	*Standardized Coefficients* Beta	t	*Sig.*
Full (constant)	291.165	23.687		12.292	.007
Age	18.270	1.793	1.000	10.189	.009
Arm strength	0.582	0.818	0.070	0.711	.551

[a] $n = 16$. Age has a significant positive effect while arm strength has no significant effect.

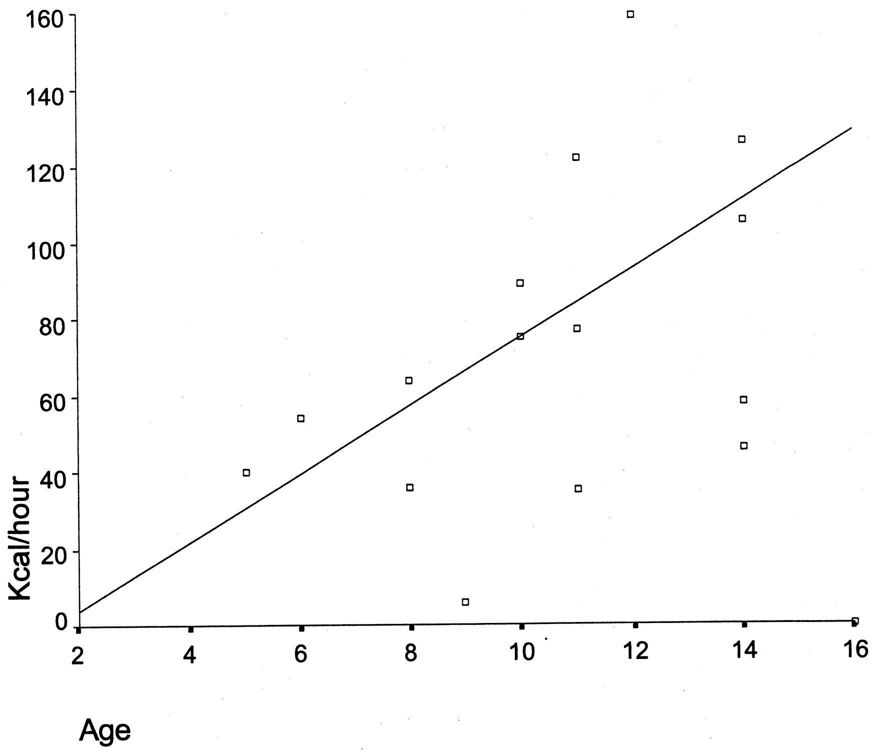

Figure 5.2. Fishing returns by age for girls. Each point represents the average return rate for a girl over the study period. n = 16, $p^2 = 0.5468$.

Table 5.3 Multiple Regression of Mean Weight of Fish for Basket Fishing on Age and Arm Strength for Girls 3–18 Years Old[a]

Model	*Unstandardized Coefficients* B	*Std. Error*	*Standardized Coefficients Beta*	t	*Sig.*
Full (constant)	–21.936	23.983		–0.915	.384
Age	–4.125	3.702	–0.331	–1.114	.294
Arm strength	8.730	2.319	1.119	3.765	.004

[a] *n* = 16. Arm strength has a significant positive effect while has age no significant effect.

Again, univariate OLS regression shows significant effects of arm strength (see Figure 5.3) on boys' return rates to fishing from a canoe. This may be due to the benefits to being able to pole the canoe into water close to the reed beds, a long distance through deeper water.

Table 5.4 Multiple regression of mean return rate for canoe fishing on age and arm strength for boys 3–18 years old[a]

Model	*Unstandardized Coefficients* B	*Std. Error*	*Standardized Coefficients* Beta	t	*Sig.*
Full (constant)	–8.896	32.438		–0.274	.787
Age	–6.358	5.291	–0.339	–1.202	.247
Arm strength	8.843	2.457	1.016	3.599	.002

[a] *n* = 20. Arm strength has a significant positive effect while age has no significant effect.

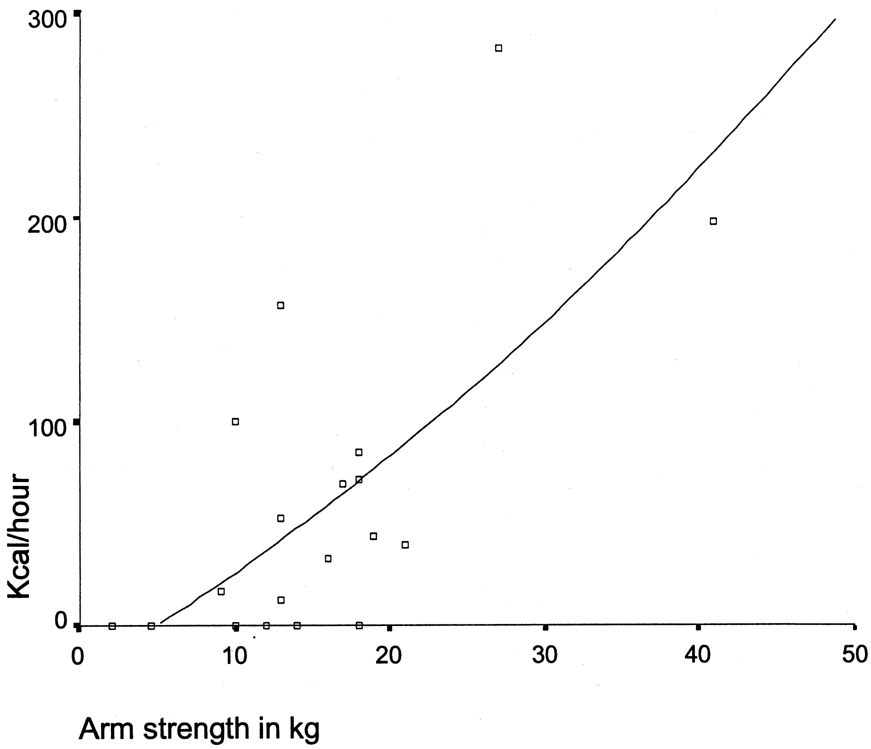

Figure 5.3. Fishing returns by arm strength for boys. Each point represents the average return rate for a boy over the study period. n = 20, $p^2 = 0.5971$.

The benefits of arm strength do not extend to catching larger fish, however. Multiple regression of return rates on age and arm strength shows that age is a significant predictor of mean weight while arm strength is not (see Table 5.5). Again, this is the opposite result of that found for girls' basket fishing and seems to be due to the differing demands of technology in

Table 5.5 Multiple Regression of Mean Weight of Fish for Canoe Fishing on Age and Arm Strength for Boys 3–18 Years Old[a]

Model	*Unstandardized Coefficients* B	*Std. Error*	*Standardized Coefficients Beta*	t	*Sig.*
Full (constant)	–201.703	87.421		–2.307	.035
Age	27.135	11.843	.607	2.291	.036
Arm strength	2.385	4.962	.127	.481	.637

[a] *n* = 20. Age has a significant positive effect while has arm strength no significant effect.

the acquisition of fish by girls and boys. Although stronger boys can move the boats close to the reeds, more experienced boys may have higher skill levels in knowing exactly where to encounter larger fish or in using the hook and line technology, or both.

Other forms of fishing

There are two other forms of fishing observed in this community, basin fishing by young girls and hook and line fishing from shore by both boys and girls. Basin fishing is performed by girls who are too young and small to use a basket. This form of fishing has very low success and there is no significant effect of age or arm strength on return rate. Hook and line fishing from shore is performed by girls when they are able to obtain hook and line and by boys who are unable to use a canoe due to their young age or missed opportunity. This form of fishing also has very low success and there are no significant effects of age or arm strength on return rate for either boys or girls engaging in this activity.

DISCUSSION

Overall, the results show that the nature of the task at hand and the type of technology employed are the major influences on the relative effects of growth- and experience-based embodied capital on task performance. In mongongo nut processing, strength only brings benefits when employed in a highly skilled way and there was no significant effect of strength independent of age. The varied effects of age and arm strength on return rate and mean fish size illustrate the importance of attempting to isolate subcomponents of tasks and to understand how each of these subcomponents independently and sequentially contributes to competency in a task. For any specific component, as the skill requirement decreases, competence ap-

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pears to be based on the strength needed to move and manipulate the technology in an effective manner. At the same time, however, it is clear that there may be benefits of experience and skill accruing simultaneously in another component of a task. While continued practice may improve performance at a task, the benefits of practice are contingent upon an individual having sufficient baseline strength, coordination, and muscle memory.

This chapter uses the punctuated development model (Bock 2002a) to examine the relative contribution of growth-based and experience-based embodied capital in the development of competency in foraging tasks. The model predicts that growth and experience will interact to affect return rates in productive tasks. In particular, the type of technology employed is expected to be a major influence on the skill and/or strength requirements for a given task. Two aspects of technology come into play: the strength needed to move and/or manipulate the technology and the skills needed to apply technology to a specific resource. For some tasks, both of these elements are present, while others are weighted toward one or the other. The effects of growth-based embodied capital, operationalized as arm strength, and experience-based embodied capital, operationalized as age, were examined in relation to competence, measured as return rate and package size, at three foraging tasks: mongongo nut processing, girls' basket fishing, and boys' canoe fishing. The study found that:

- Competence in mongongo nut processing is significantly predicted by age; arm strength is not a significant factor.
- Girls' return rates at basket fishing are significantly predicted by age; arm strength is not a significant factor.
- The mean size of fish caught by girls basket fishing is a function of arm strength; age is not a significant factor.
- Boys' return rates at canoe fishing are significantly predicted by arm strength; age is not a significant factor.
- The mean size of fish caught by boys canoe fishing is a function of age; arm strength is not a significant factor.

Mongongo nut processing is a task heavily dependent on the application of technology directly to a product. While the strength required is not great, the misapplication of the technology employed can result in serious injury, spoilage of the product, or both. Both types of fishing are also dependent on the application of technology directly to the product, but differ in that fish are mobile prey that must be located and the technology must be brought to them. The differences between girls' and boys' return rates is due to the different ways in which the fish are encountered and the differences in the way in which technology is used to actually capture the prey.

Girls have a limited range when basket fishing. They need to stay close to shore, due to the presence of large numbers of crocodiles and hippos, as well as occasional elephants and buffalo. Girls who know where fish are more likely to be present have a distinct advantage, and this knowledge is based in experience. The basket is relatively light when moving from one place to another so strength is less important for girls when locating fish. Boys face a different limitation in encountering prey when canoe fishing. The fish are plentiful along the reed beds, yet to pole a heavy dugout through the deep water to the reeds takes arm strength. Weaker boys are less likely to travel to where the fish are. Girls with restricted mobility can carry their lightweight technology to the microhabitat within their range that has the highest likelihood of encountering fish. Boys have heavy technology that has a wide range and can be brought to a larger habitat with high likelihood of encounter.

While in terms of mobility, girls have less heavy technology requiring less strength to move, in terms of prey capture girls have heavier technology requiring more strength to apply directly to the fish. While conical baskets move relatively easily through the water when they are being transported, when used to catch fish they must be moved at a much quicker pace and pushed through much deeper water. In order to pick up a large fish, a considerable amount of strength is required. Boys using hook and line, however, are not limited by strength but rather by the ability to set the hook by maintaining an appropriately light touch on the line.

These results illustrate how growth-based and experience-based embodied capital interact to produce competence. To process mongongo nuts, one has to have reached a threshold of strength. Further increases in strength, however, are unimportant compared to the development of skills in applying that strength to cracking open the nut. For fishing by both girls and boys, strength and skill have complementary and additive effects across intrinsic elements in the task. The skill and strength requirements of these subcomponent tasks are in turn heavily dependent on the technology involved. And as we have seen, the same technology can rely on skill and strength alternately in different task subcomponents. In the production of the same resource, skill and strength can contribute to food procurement through alternate and potentially simultaneous pathways.

In light of these results, we can think back across human evolutionary time and consider whether growth or learning was the primary selective force on human childhood. Or we can consider that both growth and learning are endogenously and simultaneously produced, and that the form of human childhood is the outcome of the selective advantages of the interaction between growth and learning (Bock 2002a). During our evolutionary history, benefits to children's activities could accrue to the parents or to the child in the form of immediate resource acquisition used to defray the cost of parental provisioning of the child in question and siblings, as well as to future benefits to the child in the development of skills (Bock 2002a). In any subsistence ecology, the kinds of tasks and the technology available will determine the relative contribution of growth-based and experience-based embodied capital to competence in resource acquisition. The age profile of these relative contributions will be determined by the interaction of growth and experience summed across each task.

In considering this interaction we should also be cognizant of the costs of technology. Intensive tool use, although with a very small tool kit, began with early *Homo*. Although Shennan and Steele (1999) argue that Oldowan tools are simple enough to be produced by children, by the time anatomically modern humans were exploiting highly extractive niches it is likely that the more complex technology involved was not being manufactured by any children who may have employed it. Rather, parents or other parties provisioned children with technology used to acquire resources. This provisioning is a way for parents to manipulate children's time allocation and the benefits of their activities. Prior research in this same community has demonstrated that parents manipulate children's time into different activities to realize both short- and long-term gain (Bock 2002a). In addition, technology in this community is provided by parents to offspring. The canoes used by boys and the fishing baskets used by girls were manufactured or provided by parents. Girls, in fact, are provided with baskets of various sizes as they age. Taking this into account, it is clear that when children forage using technology they may not be providing net benefits in terms of their provisioning if the cost of providing the technology outweigh the benefits of the child's foraging returns. The costs of technology production are as much a form of parental provisioning as direct supplementation.

This study helps to highlight the importance of careful assessment and measurement of features of subsistence ecology when evaluating individual resource acquisition. In particular, understanding competency requires that we reverse engineer tasks such as fishing or hunting that seem simple when viewed only as an outcome. By focusing on the details of the process of food procurement, the elements of competency can begin to come into view. This study also draws attention to the importance of integrating multiple temporal and spatial frames of reference into the analysis of any task, as well as the use of multiple currencies to understand trade-offs and opportunity costs. Future research incorporating these perspectives will help us to understand not only the lives of children in the context of local adaptation, but also how the evolved childhood provides the framework for children's developmental trajectories and their development into competent adults.

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