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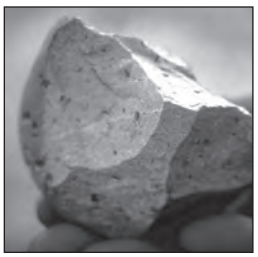
NUMBER 1

THE OLDOWAN:

Case Studies Into the Earliest Stone Age

Edited by Nicholas Toth and Kathy Schick



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COVER PHOTOS

Front, clockwise from upper left:

1) *Excavation at Ain Hanech, Algeria (courtesy of Mohamed Sahnouni).*

2) *Kanzi, a bonobo ('pygmy chimpanzee') flakes a chopper-core by hard-hammer percussion (courtesy Great Ape Trust).*

3) *Experimental Oldowan flaking (Kathy Schick and Nicholas Toth).*

4) *Scanning electron micrograph of prehistoric cut-marks from a stone tool on a mammal limb shaft fragment (Kathy Schick and Nicholas Toth).*

5) *Kinesiological data from Oldowan flaking (courtesy of Jesus Dapena).*

6) *Positron emission tomography of brain activity during Oldowan flaking (courtesy of Dietrich Stout).*

7) *Experimental processing of elephant carcass with Oldowan flakes (the animal died of natural causes). (Kathy Schick and Nicholas Toth).*

8) *Reconstructed cranium of Australopithecus garhi. (A. garhi, BOU-VP-12/130, Bouri, cranial parts, cranium reconstruction; original housed in National Museum of Ethiopia, Addis Ababa. ©1999 David L. Brill).*

9) *A 2.6 million-year-old trachyte bifacial chopper from site EG 10, Gona, Ethiopia (courtesy of Sileshi Semaw).*

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Photographs of the Stone Age Institute. Aerial photograph courtesy of Bill Oliver.

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CHAPTER 7

RULES AND TOOLS: BEYOND ANTHROPOMORPHISM

SUE SAVAGE-RUMBAUGH AND WILLIAM MINTZ FIELDS

ABSTRACT

This chapter presents the perspectives of a cognitive psychologist (SSR) and a cultural anthropologist (WMF) in assessing and interpreting the acquisition of skill in the stone toolmaking behavior of modern bonobos (Pan paniscus) in an experimental setting. These perspectives are presented as personal narratives based upon memory, notes, and video documentation.

A COGNITIVE PSYCHOLOGIST'S PERSPECTIVE (SSR)

This is a first person narrative account of the initiation and development of knapping in bonobos. It is drawn from memory, notes and video documentation. It surely leaves out much of what actually happened from the viewpoint of the bonobo knappers themselves. Yet it includes, from the perspective of intimately knowledgeable, Homo sapiens observers, the salient behavioral transitions in skill development. Like all narrative accounts, this one relies upon the insight, intuition and analysis of the observers, who are, in this case, participant observers in the classical anthropological tradition. Narrative accounts, by definition, describe events. They do not predict events, nor do they focus upon quantitative data. Good narrative accounts serve as valuable explanatory tools, permitting hypotheses to be formulated and tested, when and if events similar to those of the narration occur again. It is through movement between the processes of analytic and categorical description, coupled with hypothesis formation, prediction, data collection and finally theory formation, that the scientific understanding of behavior progresses. Because this work focuses upon the long-term rearing effects of a small number of nonhuman primate individuals, ethnographic narrative account is the appropriate research tool.

Strict empiricists (MacPhail, 1987; Heyes, 1998) dismiss narrative accounts of nonhuman primate behavior, treating them as "anecdotes." They assert that such accounts are based on mere "interpretation" rather than "actual data." Moreover, these empiricists argue that any explanatory account of nonhuman primate behavior is inevitably infused with anthropomorphism because we ourselves are primates. This fact alone is believed to make objective accounts impossible. All descriptive statements regarding the motivational states of nonhuman primates are held to be inappropriate, as they attribute some form of consciousness and/or intentionality to nonhuman beings.

By contrast, we assert that to claim that a monkey who is engaging in a certain posture and facial expression is indeed threatening another monkey (or even a human observer) is a perfectly legitimate scientific statement when made under the appropriate conditions. The interpretation of "threat" can be validated by the ensuing behavior of the other monkey, or by the human observer should the threat be directed toward them.

Going one step beyond the description above, one might also say that the monkey intended to threaten the human observer and we might offer as "proof" the fact that the threat was followed by attack when the threat was ignored. However, the empiricist would disagree with the term "intended," maintaining that the behaviors of threat and attack could better be explained in terms of

stimulus and response. "Intentionality," according to many radical behaviorists, must be exclusively reserved for human beings.

The difficulty with this view is that it is a "speciesist" argument. It limits the role of conscious intent to one species, Homo sapiens. One can just as readily explain human threat and attack as stimulus-response behavior, leaving out any discussion of intentionality. But were we to do so, human behavior would become meaningless, for most human beings have lent meaning through either expressed or inferred intent. As human beings, we tend to think, attack and threaten for very specific reasons, which we expound upon verbally. Because the empiricist does not know how to ask a monkey its intent, he or she concludes that the safest theoretical position is that the competency for intentional behavior, and explanation thereof, be limited, by caveat, to Homo sapiens.

This anthropocentric perspective overlooks two things. First, much human behavior, while explained, is not rational. The reasons given for threat and attack behaviors are often illogical and frequently, in humans, words and actions fail to coincide. Thus revealing that explained "intentions" do not necessarily explain behavior. If they did, we would barely need a psychology of the human mind. We not only permit human beings to explain their intent, we insist upon it to such a degree that individuals will offer socially acceptable explanations that have little relevance to the actual behaviors observed. In such instances, we could correctly say that "anthropomorphism" is present and clouds our view of the real explanation of behavior. In this case, anthropomorphism means the interpretation of another person's behavior based upon ones own thoughts and feelings. Such interpretations of the behavior of other human beings are as equally problematic and/or valid as are interpretations of the behavior of nonhuman primates.

Therefore, it is important to recognize that the inherent fallacy of anthropomorphism is not the species to which it is applied, but the way in which a loose subjective account fails to authentically describe the facts of the observed behavior at hand. Loose description can occur for any species, human or nonhuman. Likewise, and much more important to recognize for this chapter, is the fact that legitimate, accurate and historically informed description is equally valid for human and nonhuman beings. To say that a monkey intends to threaten another, is a statement easily validated by observing the situation. To say 'why' the monkey or the person intended to threaten another is one step removed from the immediate context, but no less valid if this statement is based upon historical analytic observations of the broader social context, where the social context is well studied and understood across time. Descriptions of intentions are no more or less valid for a given species.

Many scientists all too easily accept that we shall never be able to perceive the world of any non-human being in an adequate manner. While it is certainly true, for example, that human beings lack echo-location and thus are unable to perceive the world as does a bat, it is also the case that some human beings are deaf and blind and therefore unable to perceive the world as do others of their own species. Nonetheless blind persons frequently speak of having "seen a friend" and deaf persons will relate accounts they "heard" from others. These are not mere "manners of speech," they are statements which reflect the perceived feelings of the speaker. That is, the blind person feels as if they have seen something and even though their sensory input is different - and this feelings leads to a sensation they term "seeing."

The empiricist argument fails on a second count. It overlooks the fact that data cannot be gathered on behavior that is emerging spontaneously. During these conditions, one cannot know what form or course emergent processes will take (Savage-Rumbaugh et al., in press). One can film the behavior -- if one knows when it is going to occur or when salient events in the emergent process will take place. However, when the behavior is spontaneous and not produced by a designated environmental stimulus, filming is difficult to accomplish without cameras following the organism wherever it goes. Once a behavior has emerged and been closely observed, should this emergent process repeat itself in a predictable manner, plans can be made for data collection.

Such was not the case for tool production in bonobos. The first knapper, Kanzi did not follow the experimental trajectory that was prescribed for him. His younger sister, Panbanisha provided no opportunity for replication, as her trajectory did not repeat Kanzi's. This could have been the result of individual differences or sex differences. Such is impossible to determine without a 25-year rearing study of two additional bonobos. However, Panbanisha's alternative emergent trajectory might not be attributable to sex or individual differences, but rather to the fact that Kanzi's experience affected Panbanisha. Kanzi was the first knapper in the bonobo group, and there can be only one first knapper. Panbanisha had the opportunity to learn from Kanzi's successes and mistakes and to observe a bonobo knapping style. Kanzi had no opportunity to learn from the failures of another knapper, nor any opportunity to observe another bonobo.

To complicate the issue even further, personalities, competitiveness, and pride began to enter the experimental area. These were variables that moved the question far beyond the initial one of "can they make stone tools and how do they learn to do so." Thus in order to provide the uninitiated reader with a modicum of insight into how it is that a nonhuman species began to knap, a narrative account is essential. Without such a back-

ground, empirical statements generated by data collected on bonobo tool production exist in a meaningless vacuum. When readers cannot understand the environment that generated cultural transmission of tool manufacture from Homo sapiens to Pan paniscus they must inevitably assume that the nonhuman artifacts produced by Kanzi and Panbanisha are the result of tedious instrumental shaping, which results in a competency sans awareness. They have no basis on which to draw the proper conclusion. It is the goal of this chapter to correct that problem and to enable the reader to access for themselves the cognitive competencies and awarenesses that guide Kanzi's and Panbanisha's knapping behavior.

Whatever flaws, bumps and singular views this approach may entail, there are unique and valuable insights offered through a synthetic historical narrative. It provides the reader with a framework through which he or she can begin to understand the complexity of affairs that currently surround tool production in bonobos. By inference, we can legitimately infer that a far greater set of complex affairs surely surrounded the tool production of australopithecine and/or early Homo groups who flaked, not intermittently, like Kanzi and Panbanisha, but as a central component of cultural group survival.

This chapter is the product of a joint authorship, one author working from the methodological demands of experimental psychology and the other author applying the techniques of ethnography to a society of nonhuman primates. These perspectives, perhaps not surprisingly, result in distinctly different narrative accounts. We have only partially succeeded in being able to merge these different frameworks of thought and question into a single unified approach. Thus we offer below a historical narration of our experimental attempts to introduce stone tool manufacture to a nonhuman species, followed by descriptive narrative of the anthropological cross-cultural experience of suddenly encountering and living among a group of bonobos who produce stone tools. It is our hope that these multiple perspectives, coupled with the accompanying artifact-oriented chapter by Toth, Schick, and Semaw will provide the reader with a far more comprehensive picture of this project than has heretofore been made available. In addition, we hope it will represent the beginning a truly interdisciplinary approach to the study of human origins, as contrasted with multidisciplinary approaches that characterize the current condition of the science.

How the Project Began

The idea that a living ape might become a stone knapper was first suggested to this author by Nicholas Toth at a Wenner-Gren Conference in Portugal on the relationship of tool and language. My initial reaction was that such would not be possible. We recognized however that in the realm of behavior -- where nearly anything is possible and where the expectancy effect operates with an unseen hand -- such a view was not a sufficient reason to reject a study. So we welcomed Nicholas Toth and Kathy Schick to the Language Research Center and asked how they might wish to go about teaching a bonobo to knap stone.

It is worth noting that, as we proceeded, it was my unexpressed belief that:

a) the bonobos would not want to knap
b) that they were possibly not sufficiently manually supple
c) that toolmaking must have evolved long after a simple language emerged and that given what we then saw as the simplicity of their language, toolmaking was much too advanced for them
d) finally, that knapping was so difficult for us at the Language Research Center, that we could not possibly expect the bonobos to be able to accomplish it.

However, science is replete with the incorrect ideas and theories of those who have attempted to practice it, and we knew that we were no exception. When Toth and Schick arrived, having never worked with living apes and especially bonobos, we set aside our doubts and began working with the ideas they presented to us.

They wished to begin with an adolescent male bonobo named Kanzi. Toth and Schick had studied living Homo sapiens stone toolmakers in New Guinea, and in that group only adult males flaked stone and began to do so around adolescence. Thus Kanzi was the right age and the right sex to serve as prime stand-in for nonliving hominid knappers. Interestingly, for the human knappers in New Guinea, flaking stone was inevitably a group social activity. All learning and all practice took place in a social setting, in which the sounds of the stone against stone, the comparisons of work, discussions of the product, etc. inevitably took place. In addition, the skill of each knapper was known by the others and the tools, when finished, became essential implements to group survival.

We mention these critical aspects of human flaking solely to point out that they were absent, by necessity, from Kanzi's experience. Had they been present Kanzi's skills would surely have emerged more rapidly and with greater proficiency than they did. Thus in evaluating and comparing Kanzi to ourselves or to our earliest ancestors, we must recognize that Kanzi is at cultural disadvantage. This is not because he is a bonobo, but because he does not belong to a cultural group for whom knapping is an essential social and survival skill. Knapping is therefore not likely to rivet his attention and motivate him to excel, as it would if it were a necessary survival skill. This is not to suggest that a knapping tradition could not occur among bonobos. Quite the contrary, we believe that while such as not been observed in the field, it is certainly possible. However, we must temper our

comparisons between Kanzi and early human knappers, by reminding ourselves that Kanzi probably would behave very differently if he were reared in a knapping culture.

How, we asked would Kanzi learn to knap? Toth explained that we could build a box that would require Kanzi to make a stone tool to open it by cutting a string holding a door flap closed. We could put something inside the box and then, from outside Kanzi's enclosure, Toth would make a stone flake and demonstrate its use while Kanzi observed. From the start, Kanzi watched as Toth picked up rocks, knocked off a flake and used it to cut the string on a box that held some grapes. Toth then handed the grapes to Kanzi. Toth repeated this activity a few times and then the "string box" was brought into Kanzi's enclosure.

Kanzi did not pick up rocks and start to knap. So one of us (Sue) put a rock in each of Kanzi's hands and urged him to do so. He attempted to knap as he had observed Toth do, but made the typical novice mistake of bringing the rocks together with a horizontal motion (more or less in a 'clapping' action). He also used very little force. When Toth knaps he appears to use very little force as well. In fact, to the naïve observer, the way in which flakes fall off in the hands of an accomplished knapper appears magical. When knapping stone, one cannot succeed by simply hitting rocks together. It is a difficult skill to master, just as it is learn to play the violin. One cannot simply pick up a violin, draw a bow back and forth across it and produce music. Neither can one begin hitting rocks together and produce a tool. One must learn to use one stone as a hammer and the other as a base or "core." The hammer stone must strike the core at just the right angle and just the right speed to produce even a single flake. The first flake production determines how and where the hammer must strike to produce the next flake. The hammer blows must be precisely aimed and timed. They must be produced with a more or less controlled throwing motion rather than a hitting motion, as appears to the untrained eye.

Kanzi's rocks did not fall apart and he quickly concluded that he was unable to make a flake. We continued to demonstrate, and tempted him with extra special incentives in the box, but Kanzi refused to try after his initial failure. He appeared sensitive to failure and to resent being repeatedly encouraged to do something that he was too difficult for him. Perhaps this is too anthropomorphic an interpretation of his reaction but it has been reported that "Every researcher with apes has learned that they will balk and simply stop working if problems encountered are in any manner beyond them" (Savage-Rumbaugh et al., in press). This "balking" might best be understood as a refusal to engage in behavior whose outcome is either unpredictable or whose goal cannot be achieved.

As a result, it was decided to have Toth make flakes for Kanzi and hand them to him, to enable Kanzi to open the box. Kanzi appreciated this and readily took the tool and retrieved the incentive. Seeing how proficiently Kanzi employed the stone flake that was given to him, Toth and Schick wondered whether Kanzi actually understood something about the properties of stone tools and whether he could determine a good flake from a bad one. That is, would Kanzi be able to judge the sharpness and strength of a variety of flakes and choose the best tool or would he use any flake to open the tool site. Toth had not demonstrated flake selection and Kanzi had no previous experience with stone tools. If he were to know good flakes from poor ones already, this would suggest a preliminary understanding of stone geometry.

The tool site was baited and Kanzi was given an array of flakes to choose from. From the start he ignored the duller flakes and selected the sharper ones, generally testing them in his mouth before beginning to use them on the string. The flakes were generally small, about 2 inches in length, and it was difficult to hold them in his large hands as he cut the string. He could not cut it swiftly and easily in one motion as he did not hold the flake at a downward angle and pull it towards him as did Toth. Instead he tried to push the flake through the string, and he so doing began to wear the string away fiber by fiber. However, he quickly hit upon the idea of doing this with two hands instead of one. (Toth had employed only one.) Kanzi began to put the index finger of his left hand under the string and pull it taunt and then to "saw" the string with the rock chip. His sawing motions were limited to one direction (towards himself) rather than back and forth, but he focused on one part of the string until it separated. He did this very patiently, employing the chip even when the string was hanging only by a thread.

Development of Kanzi's Knapping Skill

Although Toth and Schick had hoped that Kanzi would immediately begin to flake, he was not dissuaded. As they left, they asked us to continue trying to encourage Kanzi to knap. After all, they reminded us, early hominids surely had not begun to do this in just one day. Everyday, for that first week after Toth and Schick left, we baited the tool site several times and demonstrated flaking for Kanzi. However, there was one difference between demonstrations by those of us who were not expert knappers and Toth. It was not easy for us. The stone flakes did not fall as if by magic. We had to use quite a bit of force as we did not know how to focus the blows or to aim in the precise way that Toth did. Hence we failed a lot and it often took many blows to produce a flake. In addition, our flakes were not as sharp as Toth's. We continued to encourage Kanzi to knap repeatedly offering him rocks. Sometimes he took the rocks and made a few apparently half-hearted attempts at hitting them together in the midplane, as if he were clapping, and then gave up. When we asked him to continue he would either hand the rocks to us or walk away and ignore us.

Kanzi is so strong, that even if he were not employing the correct technique, he had sufficient strength to break the rocks if could just employ it. So we verbally encouraged him to hit the rocks together "harder" and tried to demonstrate this. In response to our verbal suggestion he would produce one or blows that sound loud and strong, but then give up again. No matter how tenaciously we worked to in interest him or to assist him, there was no change in Kanzi's behavior for approximately 2 weeks.

Then just as we were beginning to conclude that Kanzi was not going make progress in this endeavor, we began to hear a very loud repetitive banging noise coming from the group room. We peeked in to see Kanzi, a very determined look on his face, hitting the stones together with as much force as he could muster, over and over and over again, until his arms were too tired to permit him to continue. While chips were not flying off the rocks because of the horizontal clapping action of both hands, stone powder was being created with each blow. In fact, Kanzi the first bonobo knapper, sat amongst a veritable cloud of stone powder, produced by his own efforts. Kanzi apparently had decided to try and "open" the rocks by his sheer strength alone. We use the term "decided" because nothing had changed in the situation but Kanzi himself. It took about 15 minutes to achieve the production of his first chip, a tiny piece less than 1/4 in width and just a sliver of thickness. But he used it nonetheless. However it was so small that it crumbled in his large hands before he could cut the string. Kanzi sighed, but made another flake, with similar effort, but more quickly.

That day was something of a watershed for Kanzi in that he realized it was possible for him to make a flake. We infer this from the observation that ever after, each time the tool site was baited Kanzi would pick up the stones and begin to knap. He no longer needed encouragement or demonstration. When he did not succeed, we would remind him that it was possible for him to do so. Kanzi would appear to reflect upon this and then return to the task. He also began to look the rocks over carefully and to select those with the better flaking potential according to material and angles.

All of his initial flakes were very small, and many of them broke as he tried to cut the string. He was not dissuaded and would make as many small flakes as he needed in order to achieve the task. However he did not change the plane of his blow or try to make large flakes, even when strongly encouraged to do so. Observations such as these, made across time, are neither anecdotal, nor anthropomorphic. They go beyond anthropomorphism. To say that Kanzi "realized it was possible for him to make a flake" is not a simple statement about how we would interpret his behavior at one point in time - were he a human being. Rather it is a statement, constructed across a long span of time from a multiplicity of observations. It is supported, in time, by observations of one sort before the event and observations of a different sort after the event. The nature of these observations allow them to be contrasted in ways that can be said to empirically justify a statement about Kanzi's cognitive capacity to realize changes in his own competencies in this task.

Kanzi remained content with the smallest flake and would use it until it wore away. However, the time and effort required to produce such a small flake was often very great. Often Kanzi would knap away at the stone for 10 to 15 minutes before producing the tiniest flake, and then this flake would wear away before he was finished cutting the string. He might have to exert this effort two or three more times before the string was cut. Kanzi did not appear to enjoy the effort that flaking required. Flaking was obviously tiring and difficult for him. He had to hold the stones and strike them without hitting his fingers, and he was able to successfully avoid getting chips into his eyes as well.

After a few months Kanzi began to employ his left and right hands differently. He would rest his left hand, with a stone in it, against his abdomen and then effect the blow on this abdomen anchored stone as "substrate" -- with the other stone in his right hand. This enabled him to position the stones more securely and was the beginning of a bimanual differentiation of blows, with one hand acting as the stabilizer and the other as the "actor." By resting his left hand against his stomach, he could also grip the stone without wrapping his entire hand around it, thereby lessening the odds of striking his fingers. As bonobo fingers are approximately twice as long as our own, the holding of the stone presents, for their anatomy, a unique problem.

The innovation from "clapping" blows of the mid-plane, to those which required one hand to act as a stabilizer and the other as a hammer, made it possible for Kanzi to knap longer and to produce stronger blows. Unfortunately however, because his left hand rested against his abdomen for support, the force of his blows were now partially absorbed by this own body mass. Consequently, it took even more forceful blows to produce a chip in this manner. Kanzi continued to flake, and he seemed somewhat more contended with his newfound position, but he still searched for ways to make the process simpler. The problems that Kanzi was forced to solve were not those that could be solved for him by observing Toth, because his anatomy was not human. Humans have shorter fingers and longer thumbs, which make it relatively easy for us to hold smallish stones and knap then without hitting our fingers. We also lack bonobo strength and cannot easily produce any chips by hitting the rocks together in the mid-plane. How are we to interpret Kanzi's newly-found solution -- as imitation, as trial and error, or as a reasoned attempt to solve a recurring problem of physical anatomy of knapping as joined to the bonobo form? While empiricists would suggest trial and error, we find that explanation incomplete. Kanzi was not randomly attempting to position the stone differently about

his body. He was, instead, responding to the dynamic physics of the task at hand. When he used mid-plane blows, chips were rarely produced. If, instead of hitting the rocks together, he hit one rock against another, he was more likely to produce a chip. However it was difficult for him to do this holding the rock in front of his body. He would sometimes hit his fingers, or knock the core out of his hand. By placing the core against his body, he eliminated these problems. Kanzi did not randomly try a whole set of workable and nonworkable set of solutions, but only a few different stone, hand and body positions, indicating that he understood the physical constraints inherent in the situation.

Kanzi's Innovations in Toolmaking

However, given the difficulties that Kanzi continued to encounter as a result of his anatomy, it was, in retrospect, not surprising that he arrived at an altogether different solution. One day, after the box was baited, Kanzi just sat and looked at, resting his elbow on one knee and his head in his hand. We were surprised, since he had always begun to flake in response to an incentive being placed in the box. However Kanzi did not appear disinterested on this occasion. Quite the contrary -- he assumed the classic position of the "thinker" and remained frozen for some time, his eyes fixated upon the rocks in front of him. Such a pose was most extraordinary for Kanzi. Finally Kanzi picked up only one stone instead of two. He held it in his right hand and rose into a full bipedal stance instead of sitting to knap as he normally did. We could not imagine what Kanzi was intending to do. Then he raised his arm and threw the rock onto the hard tile floor with great force causing it to shatter into more flakes than he had produced from all of his bimanual knapping combined. Kanzi at once selected a large sharp flake and cut the string on the tool site within seconds.

Kanzi had come up with a technique none of us had demonstrated for him. And it was far more efficient and produced better flakes than the one we had encouraged him to use. It is not anthropomorphic to infer that Kanzi "thought his way" to this solution. This sudden action, situated as it was, within the context of Kanzi's past knapping failures and successes, his style of placing the rocks on his abdomen, his great efforts to make tiny flakes, his intense fixation on the rocks, followed by a sudden change in technique -- all provide data supporting this inference. Moreover, were such actions taken by a Panda bear or an otter (both of whom can hold stones and sit upright), the conclusion would be the same. It is not Kanzi's physical resemblance to us that drives these conclusions, but rather the integration and nature of his behavior displayed across historical time.

We were delighted with Kanzi's innovation. It clearly demonstrated that for Kanzi, the end result of producing a flake was well understood. Even more importantly, it revealed that he could invent a method of flake production on his own. Critically, his innovation did not result from trial and error or even from play. It was a direct response to difficulties he encountered using a human technique with a bonobo anatomy and it was far more efficient, for his purposes, than what he had been taught to do. This meant that living apes have the potential to begin production of simple stone tools without human intervention. While it is true that we designed a task for Kanzi which required a tool, that fact is simply a byproduct of his captive environment. One can easily imagine bonobos being placed in a setting where the hunting of meat became essential, for either cultural or environmental reasons. Individuals with broken, worn or small canines could begin to utilize sharp flakes and then to throw stone to make flakes as needed. As Toth et al. (1993) suggest, the earliest stone tools in the archaeological record may be more difficult to identify than previously assumed, since flakes made by throwing are not as readily distinguished from natural rock fractures as are knapped flakes.

Nonetheless, in spite of Kanzi's informative triumph, Toth emphasized the need for Kanzi to utilize bimanual percussion, however difficult, so that the work of a living ape might be adequately compared with hominid flakes that were certainly not produced by throwing. When one throws a stone and it breaks open into many pieces all at once, it is not possible to reconstruct what was in the mind of the toolmaker at the time. However when the flakes are removed, one at time through knapping, the entire process can be directly reconstructed by putting the stone back together. The pieces of the stone become a three-dimensional puzzle, and as the puzzle is worked (backward as the stone is reconstructed), it is possible to see just what the original knapper saw, the striking platforms as they appeared to him, and the selections he made at each point. Accomplished knappers such can readily detect the expertise and thought process present in the mind of the original toolmaker, through these methods.

Some archaeologists (Davidson and Noble, 1993) have argued that simple flakes and even early Acheulean handaxes reflect only a dim awareness that striking rocks together can result in flakes that have sharp edges. However, as we have learned from Kanzi, throwing the stones on a hard surface produces a similar result and is much more efficient. Therefore, the question of why our hominid ancestors elected to knap, rather than throw, arose. There is only one value of knapping over throwing if one desires a flake. Knapping is a far more precise process and depending upon the skill of the knapper, it can be employed to produce flakes of desired size and shape. However, such intentional production of sizes and shapes would appear to require planning and skills not attributed to the earliest hominids by most anthropologists.

The difference in our enthusiasm over Kanzi's novel solutions and Toth and Schick's interest in the products of Kanzi's actions may highlight some epistemological differences between psychology and

archaeology as a subdiscipline of anthropology. Psychologists begin with questions about the mind, its contents and the nature of learning. Archaeological anthropologists begin with evolutionary questions of the origins of human mind. Some psychologists look for continuity of learning processes across species, others postulate a sharp divide between human and nonhuman learning. Anthropologists attempt to situate the human/nonhuman divide in evolutionary time and to look for some archaeological evidence, such a fire-making to support their position. When fossil and artifactual evidence change coincidentally, as in the case of the appearance of stone tools, speculations regarding the emergence of new cognitive capacities appear warranted. Psychologists rely heavily upon detailed experimental methods of "task presentation" to investigate learning and cognition. Anthropologists interested in fossils and human cognition must reply upon inference from fossil and artifact discovered in context. Anthropologists working and living in hunting and gathering societies are able to learn and speculate about the lifestyle that early hominids might have utilized, relying on participant observation and ethnographic techniques. These methodological differences, driven as they are by the actual physical and social material available for study in the different disciplines, result in fundamentally different orientations toward mind. That of the psychologist is oriented around questions of individual capacity and development. That of the anthropologist is oriented around questions of cultural change across time, and archaeologists necessarily must also rely upon physical prehistoric evidence for their inferences.

Thus there was delight in the processes of mind which Kanzi displayed, but no direct means of linking such processes to the archaeological record unless Kanzi produced stone flakes through bimanual percussion. The process of one mind, while it may reflect potential and creativity, cannot be equated with culture as process of group adaptation.

Thus, in spite of Kanzi's innovative solution, we joined together in an empirical decision. As stone tools in the early archaeological record show evidence of manufacture by bimanual knapping rather than by throwing, in this phase of our "experiment," Kanzi would be required to knap and would not be permitted to throw. While our logic for this decision was impeccable, it was not clear how we would achieve this goal. Our first approach was simply to ask Kanzi to knap rather than to throw. Most students of animal behavior would look askance at such a decision, and concentrate instead on effective shaping procedures. However, psychologists working with human subjects typically request participation of a specific sort during an experiment. Kanzi was not human, but he could understand verbal requests. Such requests served, as they do with human beings, a much more simple way to achieve a particular behavior than shaping techniques.

He understood our request and accommodated our expressed desire by hitting the rocks together a few times without achieving a flake. Then, as if to emphasize the effectiveness of his own technique, he slammed the rock on the floors, producing an array of flakes, and then looked directly at us and gestured toward his accomplishment. We tried a few times to insist verbally that Kanzi knap rather than throw. However, having once demonstrated the efficiency of his technique, Kanzi proceeded to ignore us. When we baited the site, he did not bother to knap or to listen to our imploring. He threw the rock, made his chip, obtained his incentive, and then walked away, all in a matter of minutes.

Kanzi had obviously had made up his mind regarding the relative efficiencies of the technique we taught and preferred (for its comparability to toolmaking responsible for the early archaeological record) versus the one he devised and preferred, on the rational basis of his own toolmaking efficiency. Perhaps an empiricist would wish to argue that we were being too anthropomorphic in our interpretation of Kanzi's behavior. However, Kanzi did not have to make his choice so clear. He had several months of practice and reward for knapping and only one experience with throwing. Yet that experience, preceded as it was by thoughtful steady gazing upon the rocks, changed his behavior unequivocally from that time forward. If reward-based experience were driving his behavior, he should have fallen back on knapping, not really understanding what he had done.

Realizing that we were at a major impasse in the work, we attempted to devise an experimental method to force Kanzi to abandon his own solution. (In retrospect, and with our current knowledge of Kanzi's cognitive awareness, we might have done best to simply explain to Kanzi that we were performing an experiment in which we needed him to knap rather than throw. This method seems to be one that Kanzi's prefers us to employ to engage his cooperation at the current time.)

Thus we determined to alter the environment so as to make Kanzi's technique less efficient than our own. To this end we carpeted the entire group room floor with blankets, so that any stone would bounce against the softer surface, rather than flake into pieces. Kanzi entered the room and observed the soft blanket covering on the floor. We presented Kanzi with a baited box and with stones, assuming that he would throw a stone on the floor only to find that it bounced off the blankets and not shatter as he had intended. He proceeded to make a few half-hearted attempts to throw stones onto the blanketed floor, but he did so with noticeably less force and enthusiasm than he had thrown stones onto the hard tile floor, as if he anticipated less success in the current circumstance. The stones bounced off the blanketed floor without shattering or producing any useful flakes. We then encouraged him to knap with both hands, and he then made a few attempts at bimanual knapping. After a short time attempting to knap the stone, Kanzi

then got up and attempted again to throw the stones on the blanketed floor. After a few futile attempts to shatter the stones in this way, he walked to the edge of the room and carefully pulled a few of the carpet blankets loose from their tape to form a hole in the blanket covering, thus revealing the hard tile floor. He then threw a stone into this hole and succeeded in producing a number of flakes.

From his initial reaction to the blanket-covered floor, it was clear that Kanzi had surmised, just as we did, that a stone thrown against a soft surface would not shatter. He had no previous experience throwing stones against soft surfaces, nor had he observed anyone do so. Yet he seemed to have a cognizance of the properties of the materials he had been working with and he behaved accordingly. Some empiricists might object to this interpretation, but it is not one based on simple anthropomorphic tendencies. The anthropomorphic assumption of the experimenters planning the procedure was that Kanzi would throw the stone on to the carpet without realizing that it would bounce. Kanzi, in this case, went "beyond anthropomorphism" in his first reaction to the blanketed floor and in his eventual solution to the problem presented to him.

Why did we think that he would not realize the new properties of the changed situation, and why did we assume that he would simply throw the stone, find it would not break, and then simply revert back to bimanual percussion? We did not grasp Kanzi's comprehension of the physics of about the task in which he was engaged. The story of Kanzi's life is one of "experimenters" and "care-takers" repeatedly underestimating his cognizance of the situation at hand and his overall intelligence (Savage-Rumbaugh and Lewin, 1994). Even though we have made similar mistakes in the past, we continue to make them in new situations. We did not generalize what we had learned about Kanzi's linguistic abilities to his potential toolmaking ability. In the terms of learning theorists, we "failed to generalize to a new situation." Such failure to generalize is often characterized as the hallmark of animal thought, as contrasted with human thought (Rumbaugh, 2003).

While we deliberated what our next experimental step should be, Kanzi's facility with throwing enabled him to make large flakes quickly and easily. His quick fashioning of large, efficient cutting flakes permitted us, in turn, to increase the thickness of the string Kanzi was required to cut. Initially, the string was ¼" thick. With the larger sharper flakes produced by throwing, Kanzi was easily able to cut it. Slowly the diameter of the string was increased until it was over an inch in thickness. For such a thick string or rope Kanzi needed very large, strong, sharp flakes. Kanzi responded by selecting his material even more carefully and throwing it much harder. He began to ignore completely the small chips he hasd earlier worked so hard to produce. Anything under ¾" came to be treated as debris by Kanzi.

During the "throwing phase," we noticed that initially Kanzi displayed no arm bias or preference. However, within a few days he settled upon the right hand and never again utilized his left for this task. A review of the video tape of this short transitional period revealed the origin of the right arm bias. When Kanzi stood bipedally and employed his left hand to throw, his right arm rather automatically moved upward and forward and across his body, mirroring in a slightly delayed manner, the motion of his left arm. However, the same throwing motion with his right arm did not evoke a mirroring motion of the left hand, which rested in the normal position beside his body while Kanzi threw. This difference in the motion of the opposing hand during throwing was observed only when Kanzi stood fully erect while simultaneously executing a throwing motion of considerable force. The need for the right hand and arm to follow the motion of the left hand and arm, but not the inverse indicated the existence of a neurological basis for the development of Kanzi's right-handed preference. It is not known, of course, whether a similar constraint existed among early hominids for they were more proficient bipeds than Kanzi. The follow-through movement of the right hand-arm occurred as though it were part of the locomotor pattern of motion. That is, if Kanzi were brachiating, and he moved the left hand forward to catch a branch, the right hand would need follow in patterned precision. Kanzi was apparently able to inhibit this primitive motor pattern when leading with the right but not when leading with the left hand. This fact might support Calvin's view that it was precision throwing which placed pressure on the nervous system for extreme hemispheric specialization and for the development of the rapid sequencing capacities that underlie music, grammatical construction, dance and many other activities thought to be exclusively human.

When the weather grew warmer, it permitted us to once again attempt to exert empirical control over Kanzi's knapping methodology. The outdoor play area had a yard covered with bark, and we planned to place stone tools there while also blocking Kanzi's access to the indoor stone floor. We believed that this procedure would force Kanzi to abandon his throwing technique and revert to bimanual percussion. Bark, unlike carpet cannot be removed, for under it one finds only more bark. We quickly found that we were mistaken and that we had yet again underestimated Kanzi's ingenuity and creativity.

The first time he encountered the need to make a stone tool in this new location he visually surveyed the entire area, looking for a hard surface against which to throw the stone. He noted the large pole which held up the chain link cover and threw the rock at the base of this round pole. The rock glanced off. Kanzi then looked around the area again. It seemed that there was nothing left for him to do but to try bimanual percussion. There were some steel tables in the enclosure and a small pool,

but no horizontal flat hard surfaces like the tile floor indoors. This fact did not trouble for Kanzi for more than a few minutes. Again he paused in thought, then calmly walked over to the rocks in the enclosure, selected a large stone from the group positioned it directly in front of him. Then he picked up a second stone and threw it against the first! It did not shatter immediately, but within 3 more throws, Kanzi had produced a nice large flake, without knapping! Kanzi had expanded his throwing technique to include two stones, one as substrate and one as hammer.

This innovation required a much more precise aim that simply throwing onto a hard floor. Initially, Kanzi missed the target stone quite frequently. However, after a few days of practice he became as proficient at this technique as he had been at throwing a single rock onto the floor.

Interestingly, Kanzi did not stand bipedally when throwing one stone against the other as he had done when he threw rocks against the floor. Instead he assumed a quadrupedal stance about two to three feet away from the target stone cobble. By this time, he had settled firmly into a right-handed technique. His left hand was used to support his body in a tripedal stance as he threw. Kanzi's remarkable ability to visually see the pieces of stone fly apart as the blow shattered the rock became even more apparent with a bark floor. Small chips flew rapidly away from the stone in all directions and into the bark, seemingly becoming invisible. On many trials all we observers could discern was one stone smashing against the other and the remains of the impact on the stones themselves. The flakes seemed to vanish. Kanzi however, must have been able to see flakes as they flew -- several feet in different directions in the bark. For, immediately upon breaking the stone, he would head toward a precise location and quite often, without any visual searching behavior whatsoever, he would pick up an excellent flake that was partially hidden the bark. Daily and with great ease, Kanzi located chips that flew into bark and completely out of site to us. His visual capacity to perceive rapidly flying small objects was clearly considerably more developed than ours. What evolutionary advantage, we wondered, does this skill provide bonobos in their forest habitat and why have we lost such a capacity?

Kanzi's solution of throwing one stone against another to overcome the carpet of bark yet again demonstrated his ability to come up with a functional innovation that had not been taught or even demonstrated for him. In many ways this solution was more impressive than the innovation of throwing, or moving the carpet aside. Throwing required Kanzi to consider the hammer stone, its trajectory and the target stone. This technique required the consideration of two stones, their relative positions and trajectory. This was also a technique used on occasion by our hominid ancestors to break stones too large to knap bimanually. Clearly, if Kanzi were in the forest and he needed stone tools to survive, he would be able to produce them. Toth's initial demonstrations served to reveal to Kanzi that rocks could be broken and that such breakage resulted in sharp edges. In the forest, knowledge of the properties of stone could arise by other means. One would only need to observe a rock break when it fell and to note the sharp edges produced. Kanzi's behavior to date would suggest quite clearly that he possessed the capacity to reason his way to stone flake production.

We do not pretend to suggest that Kanzi's behavior has answered the question of how our ancestors began to make stone tools. We do believe however, that Kanzi's behavior casts doubt upon the commonly held assumption that hominids before 2.5 million years ago did not have stone tool cultures because they are not cognitively competent to do so.

Kanzi's second success in foiling our experimental attempts to force bimanual percussion left us puzzled. If we were going to provide Kanzi with a least two stones, as knapping required, how could we keep him from throwing one against the other when his method produced sharp flakes more efficiently than knapping? Of course, we could reward him only for knapping flakes produced by knapping rather than throwing, but denying him access to the tool site until he had knapped. From the perspective of simply artifact comparison, it did not matter what motivated Kanzi to flake bimanually, only that he did so. However, it was also the case that to the extent we were retracing -- even in some minimal and artificial sense -- the emergence of stool tool production in ancestral hominids, it would be certainly inappropriate to force a less efficient technique upon Kanzi by arbitrary means. Equally important was the fact that Kanzi's techniques had been self-generated. He understood them and preferred them. If he were in the wild he would have continued to employ them as long as they were effective for the desired ends. We needed to design a situation that called for knapped flakes rather than simply sharp flakes.

We attempted to visualize a situation that might have induced a similar need in our ancestors, had they, as had Kanzi, hit upon the idea of throwing one stone against another and found that throwing produced perfectly acceptable sharp flakes. At first, it seemed that the only possible reason would be the need for a more precise tool or one with a predetermined shape. Such specific shapes could not be achieved consistently except by intentional design and systematic flaking with the geometry of the desired flake clearly in mind. Kanzi's geometrical needs were simple, a large sharp edge. More rapid forceful well-aimed blows achieved that goal quite well. Of course if stones were rare and had to be carried long distances, it would become essential to get the maximum number of flakes from each stone and to get a single flake when needed. One could not afford to waste material by simply smashing it apart.

Many archaeologists have assumed that the earliest knapped flakes did not reflect any intent to produce a flake of a specific size or form. However, Kanzi's efficient throwing technique cast strong doubt upon that assumption and upon that of Davidson, as well, who suggests that even Acheulean handaxes were not a product produced by intentional effort on the part of the knapper. Archaeologists believe that the main purpose of flakes and handaxes was for skinning and butchering meat. Most stone tools are found near old lake beds, where groups congregated, perhaps attracted by large hoofed stock that came there to drink.

There is another property of water that might affect stone tool production. If prey were killed by drowning and then brought to shore, it could be too heavy to move very far. Butchering around water would inevitably result in tools falling into water. Moreover, throwing one rock against another would not work.

We began to wonder how being around water might have affected tool manufacture and the need for handaxes and decided to put Kanzi's rocks into his small wading pool which was approximate two-and-a-half feet deep and eight feet wide by ten feet long. If he tried to throw one stone at another while the rocks were in the water, it would not work. He would either have to get and take the rocks out to throw them, or employ bimanual percussion. We thought he would take the rocks out, but it nonetheless this situation would pose an interesting problem for him. This experiment was set up on a very hot summer day, a time when Kanzi enjoyed being in his pool anyway. Kanzi entered the tool site area and quickly noted that the rocks were not in their usual location. He looked around and quickly spied them in his pool. He stepped and stood bipedally in the water looking down at the rocks. He picked up one stone and looked at another on the bottom of the pool and raised his hand as if to throw. Had he done so, the water would have prevented success. However he did not do, he paused, leaned down and picked up a second stone and began to percuss bimanually while standing. Even when he was bimanually percussing before he began to throw, he had not stood bipedally while doing so. When he finished his chip it fell into the water. Kanzi saw it, leaned down into the water to retrieve it, and then stepped out of the pool to open the tool site. Clearly Kanzi could have taken his rocks out of the pool and thrown them. He had been throwing now for nearly eight months without any bimanual percussion. His shift from throwing to bimanual percussion was as precipitous and dramatic as was his shift away from percussion to throwing. It was also hardly possible to conclude that Kanzi could not reason sufficiently to move the rocks out of the pool. Kanzi easily carried rocks long distances. When we went into the forest, he would often place rocks in his backpack and carry them to the tool site located in the forest. When playing alone in his enclosure he would frequently gather and move rocks. Moreover, we noted later that if we left rocks both inside and outside the pool, Kanzi would occasionally stand inside the pool and percuss or throw a rock obtained from the water toward one that was already on the ground.

But the most critical factor that emerged from this "experiment" was that Kanzi's percussion techniques were now quite different than his earlier efforts. No longer did he "clap" the stone together in the midplane. His left hand stabilized the anvil and the right hand produced a glancing blow with the hammer stone against the anvil, much as might a human knapper. Immediately and easily Kanzi produced a sizeable flake. It appeared that the "throwing period" had provided Kanzi with some very new abilities that were, all at once, utilized when he began to percuss while standing in water. He could now throw with force and while aiming with precision. In the water, his left hand provided the stationary platform for the anvil stone, and his right hand delivered blow of the hammerstone with considerably greater force and precision. Kanzi did not actually let go of the hammerstone but the motion was more of a controlled throw, as opposed to the holding and hitting motion he previously employed. Equally important, Kanzi seemed to have learned something about the geometry of knapping as he now tended to strike toward the edges of the core rather than the center. He seemed to understand the need to knock chips off the edge rather than simply "split the rock." Apparently he had acquired these skills while throwing, even though throwing itself did not require the confluence of the abilities that he now brought to the task of knapping.

Not only was Kanzi now a much more efficient knapper, these innovations made the task more enjoyable for him. For the first time since he had innovatively developed the throwing technique, he began to elect to knap rather than throw, even when the stones were no longer in the water. Sometimes he alternated between these techniques, but he slowly began to prefer knapping. The preference for knapping appeared to be a function of his increased understanding that flakes were produced by hitting the core in a precise way. Once he understood the basic principles of where to hit in order to produce a flake, he also realized that it was necessary to hold the core and rotate it to achieve the best striking platform for each blow. Clearly, core rotation and orientation for the next blow was not possible unless one held the core. Kanzi also began to make multiple flakes from the same core and would now make them readily upon request, until the core was reduced to rubble, even when no incentive was in the tool site.

Having finally achieved, all of the basic skills that knapping required, Kanzi settled down into a pattern of right-handed bimanual percussion and continued to improve his technique. He began to pay increasing attention to the angle of his blows and to the striking

platform for each blow. He also began to rotate the striking platform after each blow to achieve the best striking surface, and he paid close attention to the surface he selected. As his ability to flake increased, he came to ignore small and medium-sized flakes, attending only to the larger ones, as he now wanted not just any tool, but an effective and efficient tool. His increased competency provided him the luxury of desiring a really effective flake.

Panbanisha, Kanzi's younger sister was not initially a subject in the experiment devised by Toth and Schick. Kanzi started as the initial subject in this study due to his greater age (nine years old at the experiment's inception) and greater strength. However, because Panbanisha was with Kanzi much of the time, she often showed an interest in his activities. When we encouraged her to knap, though, we encountered the half-hearted attempts that characterized Kanzi's earliest behavior, before he was able to obtain, on this own, his very first flake. Moreover, when these pale attempts produced no flakes after only a few attempts, Panbanisha would put the rocks down and refuse any further attempts. Consequently we ended up making tools for her and handing them to her for nearly a year, with no improvement in either interest or competency on her part. There were no moments of epiphany, no sudden solutions, no throwing, nothing. Panbanisha would simply make a few meager inept attempts to knap, and then hand the rocks to the experimenter. She did not seem to like the hardness of the rocks, the sound or anything at all about knapping. No amount of encouraging her could change this behavior.

We continued occasionally to place incentives in the tool site for her and to make flakes for her that she could utilize, however this only seemed to increase her dependence upon us rather than to motivate her to achieve knapping on her own. Then during a visit of Toth and Schick, we happened to notice that Schick knapped a bit of stone as she was explaining a point about knapping. Until this time, all knapping in front of the bonobos had been done by Toth. However we noticed that Panbanisha was sitting quietly yet taking great notice of Schick (a female knapper) and so we asked her to demonstrate knapping for Panbanisha. Panbanisha continued to watch Schick with great attention, though her glances were from the side and intermittent, almost as if she were shy. When asked to knap herself, she politely refused but continued to observe. Panbanisha lacks the over ebullient enthusiasm that Kanzi brings to anything upon which he focuses his attention, and she prefers display only skills which can execute competently, especially in front of others.

Later, after Schick left, she began to practice her knapping with the intent of making a flake. That is, instead of tapping the stones together in a gestural manner to illustrate that she was complying with our request, she began concentrating on the stones themselves and the goal of producing a flake. From this point forward, she always selected one stone as the hammer and the other as the core. She often held the core with one foot and the hammer with the opposing hand. Unlike Kanzi as this stage, she began to rotate the core, looking for the best striking platform, illustrating that she had some understanding of the properties of the core's platfrom that had not arisen from direct knapping experience, as had been the case with Kanzi.

Using these methods, she frequently produced fairly large flakes. She did not move gradually from small to large flake as had Kanzi, but produced a variety of sizes from the start because she focused upon the edges of the core rather than simply hitting the rocks together in the midplane with considerable force as Kanzi had done. Since she did not have Kanzi's strength, this technique, had she employed it, would not have been effective for her in any case. From the beginning, Panbanisha also employed glancing downward blows, using the hammerstone as a true hammer, rather than as another hard surface as Kanzi had done.

Schick was not the first female knapper that Panbanisha had observed. All of her caretakers were female and all of them had repeatedly demonstrated knapping for her. However none of them were expert knappers, nor did they have the status of Schick, an important outside female visitor who was especially interested in the bonobos, who filmed them and who, much to Panbanisha's surprise was an expert knapper. Somehow this experience seemed to legitimize the activity of knapping for Panbanisha in a way that the knapping of Toth had not done. This sensitivity to role-related tasks was not something that we had previously recognized in Panbanisha. While we were certainly aware that she was quieter, far less rough in play than Kanzi, and preferred very different toys, we had not internalized the significance of the degree to which she took females as her role models. We also had no awareness of the fact that the expertise and status of the female model was itself could be an important component of the desire to emulate.

These extremely simple observations alone illustrate starkly many flaws in the classical experimental approach to the study of novel emergent behaviors in apes. These findings most probably hold true for all complex and highly intelligent organisms. Had we assumed that shaping was needed to induce knapping in Kanzi, we would have gained no understanding whatsoever of the ingenuity and comprehension of physics that Kanzi would bring to the task. By shaping him, and reporting on the success of our procedures, we would have simply verified our own anthropomorphic bias of "man the toolmaker," and revealed that an ape needed considerable training that our early ancestors could not possibly received.

If we had compounded this error by increasing our N, to improve our reliability, and put Panbanisha

through the same training regimen that we employed for Kanzi, we would have leaned even less. We would have come closer to authenticating our predetermined views of the grandeur of human mind as contrasted with the paucity of that of the apes. (See Povinelli, 1996 for a classic description of the current anthropological thought regarding the difference between human and ape minds and for experimental methods that serve to verify this conclusion).

The emergence of stone knapping in Panbanisha also produced another unexpected result, jealousy on Kanzi's part. Prior to the time, he was the undisputed stone tool knapper of the group. He received profuse praise and attention for this activity. He was repeatedly filmed and photographed, and much time was spent with him to encourage him in these endeavors. While he did not mind Panbanisha knapping now and then, if she did so with vigor or for an extended period of time, he would often interrupt her by displaying towards her. He also began to make tools and leave them for her so that she did not need to make her own tool to open the baited box.

Thus we encountered not only the need for a female of high status and ability to motivate Panbanisha, we also encountered responses on Kanzi's part which, had they occurred in a natural cultural setting in which flintknapping was linked to survival and way of life, would clearly have lead to role dichotomization of stone knapping. Significantly, such role dichotomization would not be based on physical on mental sex-linked differences. Panbanisha began knapping at a higher skill level than Kanzi and produced larger, sharper flakes. However her ability was not the deciding factor regarding whether or not she would become a skilled knapper. Kanzi intervened on two fronts, one by directly interfering with her attempts from time to time and two, by providing her with tools. These actions, though relatively infrequent on Kanzi's part, were sufficient to cause Panbanisha to diminish tool production efforts. Certainly, whenever visitors were present and Kanzi and Panbanisha were housed together, only Kanzi produced flakes as presents for visitors. Thus many people have a piece of stone flaked by a bonobo as a reminder of their visit to the Language Research Center, but all such mementos have been flaked by a male bonobo.

Toward a New Methodology in Ape Research

We have learned more than we ever suspected possible from the simple question of whether or not bonobos could learn to flake stone. The answer to that question is yes, but if that were all we had learned, it would mean relatively little. The most important findings have emerged without experimental design or prediction. Had observation not been a part of our methodology, or had observation been limited to predefined classes of behavior, derived from the limited perspectives with which we began this undertaking, we would have learned almost nothing of importance. These simple facts argue convincingly for a new methodology to be applied to the study of complex behaviors in nonhuman animals. We must move away from the delimited paradigms employed by empiricists. These paradigms begin with the faulty assumption that we cannot know the minds of other species, and therefore we will be fooled if we attempt to attribute thought or intentionality to other than ourselves. This is anthropomorphism in the extreme and if we do not move beyond it, we will only continue to glory in false self-fulfilling distinctions between ourselves and other complex beings that are more like us than we have dared to admit.

This new methodology for the investigation of complex cultural, linguistic and tool behavior in other species should:

a) include long-term observations that span important developmental processes
b) take place in group settings because no complex behavior evolves in a social vacuum
c) entail flexible observational schema that do not limit what is seen, understood and recorded
d) incorporate the perspective offered only by historical narrative
e) have a specific behavioral goal that is clear to participants and researcher, but permit flexibility in the achievement of that goal.
f) utilize participant-observations approaches when possible
g) strive to be free of anthropomorphic biases which characterize our species and which had traditionally prevented us from understanding other species
h) recognize that the majority of learning is not always manifest quickly or under precise experimental conditions comfortable to the experimenter who operates under fixed time constraints in which a behavior must occur or not occur in a given set of trials or presentations
i) maintain a flexible give-and-take between observed and observer and between what is searched for and what is found

Ethnographic Facts: An Inside Point of View (WMF)

The above account of the emergence of Kanzi's knapping skills reflects a psychological bias, focusing as it does, upon skill emergence and the interface between "experiment" and emergent behavior. The "we" is employed, on the one hand, to reflect the fact that a number of different people observed and participated in Kanzi's journey to proficient knapping across the 8-year period it took him to achieve the status of accomplished bonobo knapper. It is employed on the other to represent a sort of "communal agreement on the events observed"

and to lend an objectivity and depersonalization to the account. Objectivity in description is considered essential to basic psychological method. It is a critical orientation and precept of the discipline. By design therefore, the psychological perspective inevitably leaves aside is the subjective experience of both Kanzi and his observers. It focuses tightly upon skill emergence, leaving all else aside.

By contrast, the anthropological tool of ethnography utilizes as foreground all that psychology pushes to the background. The subjective experience of the participant observer, presented in the first person, is the central vehicle through which all else is expressed. Ethnography, as a tool of anthropology, acknowledges and celebrates the change that occurs in observer and observed. This is because of a deep understanding and recognition of the role of culture in the interpretation of all behavior. While many psychologists, especially evolutionary psychologists, speak of culture and admit to the role it can play in shaping the lens of observation, there is still a general failure in the field to understand culture in the deeper sense as a basic force driving group interaction at an often-unconscious level. Only in moving between cultures, can this unseen hand begin to be recognized, and even then the recognition, as it begins to occur, so changes the observer that the more assimilated and knowledgeable he or she becomes, the more difficult it is not to have one's vision bent by the lens of the culture. Thus, the "transition period," as one moves into a new culture is frequently the most difficult time and yet the most important, if one in retrospect can sincerely grapple with the changes which occurred during this time.

These changes are necessarily subjective and personal, for the lens of culture must operate at this level. To explain it rather lightly -- Culture is not how you wear your blue jeans or how you drink your tea. Culture is why you wear your blue jeans the way you do and why you drink your tea the way you do and how you and others feel about it as you do it. That is, culture is not so much about what you do or how you do it, but rather why you do it the way you do and why you feel as you do when you do it and what others feel about you as you do it. This kind of information is clearly absent from the account of Kanzi's knapping emergence presented above. The participants are sufficiently emic to seemingly be unaware of anything other than the need to account for Kanzi's actions in a formal manner and to justify their use of terms. While worthwhile, such an account does not draw the reader into the world of knapping bonobos. It may leave the reader with a sense of what Kanzi can do and how he came to do it, but little else. What is Kanzi really like, what is it like to be with him and to knap tools with him? How does he feel about the process, and what role does it play in his life? To answer questions such as these, a different perspective is needed. In order to fill this gap, the second author, who arrived after Kanzi had become an accomplished knapper, offers the reader an ethnographic account, written in the first person, and filled with the subjective "stuff" of what it is to be a part of Kanzi's world.

Impressions of a Bonobo Knapping Culture

When I met Kanzi several years ago, I felt as though I already knew him. I had seen the NHK (Japanese Broadcasting Corporation) documentary illustrating all of his abilities, and like a fan meeting a celebrity, we projected a romantic illusion of who we thought Kanzi was. Kanzi, on the other hand, knew I was green and ignorant and had so much to learn. In reflection, I believe he also saw a potential in me and sought to guide me. A potential, I might add, that took human others much longer to detect, including myself. He knew that I did not understand him, but he believed I could. I suspect he picked me to become one of his many spokespersons and ambassadors, a position I am honored to assume.

Those early misconceptions, beliefs, and thoughts of mine were contoured through four-field anthropology. I came to Kanzi believing that his linguistic competencies were no more than an antecedent of human language and tool expression; and therefore, associatively, he must have in his cognitive possession a type of proto-culture. And so I arrived at the Language Research Center (LRC) with the hopes of conducting the first pseudo-ethnographic interview with a non-human primate, a kind of cuteness which today I find so offensive in others. Quickly, it became very clear to me that Kanzi and his family, while they are not human, are in fact persons, and the entire notion of antecedents to human language, culture, and tools is quite faulty. Moreover, the notion of proto anything emerged as ridiculous and absurd. In time, it became quite clear that the description set which might be applied to Kanzi and his family could not be exclusively interpreted in terms of biological change over time. Eventually and fortunately, in those first days with the bonobos, my subjectivity took over. In my common experience and perception there were violations and exceptions to everything I had been taught. Epistemologically, I fell apart. Kanzi and his family, socially and culturally, violated my deeply held beliefs about the world.

Today I have reassembled myself, and let me state from the outset, I am biased. I have a new cultural bias, for I am a part of a Pan/Homo cultural world in which I now have a non-human child and Kanzi is my son's uncle. I have an emic perspective. There is extreme subjectivity in my perception of Kanzi and his family that only a postmodernist can appreciate. After Varela, known for his studies of cognition, consciousness and mind, I take subjective experience quite seriously. However, in this moment, I will try and step back in time to an empirical past that I believe is informative and speaks to issues that may lay a foundation upon which I may persuade you to consider that Kanzi and

his family are toolmakers in the very sense that humans make and use tools.

Nicholas Toth and Kathy Schick came to Kanzi's world in May of 1990. Many describe Toth as teaching Kanzi how to make stone tools by showing him how to do it. Often I am shocked at conferences by questions about Kanzi's stone toolmaking, trapped in the rhetoric of trials, respondents, operants, and even worse, "monkey see, monkey do." Ultimately, this trajectory of questioning focuses on how long it took Savage-Rumbaugh to shape Kanzi's behavior so he could flake tools and on whether I think he is conscious of what he is doing. As if I could prove my audience is conscious by the questions they ask. I am not being facetious here. The questions I am asked are almost identical and appear to have the quality of a response to a stimulus. These questions have less creative variability than Neanderthal tools. It would appear that these inquiries are generated from a perspective learned long ago before science informed the questioner's opinions - a kind of first cause scrutiny that they do not apply to their own disciplinary assumptions. Therefore, I tend always to be astonished by the distance between the human world and the local world of the bonobos I know. It would seem that the entire world is a 1960's psychologist primed with terms like training, reinforcers, and cueing, and armed with an offensive anti-intellectualism and amateurish speak, dated and stale. In addition, what seems to be commonly missing on the part of many humans in their attribution of Kanzi is the idea of his personhood. If those in my audience could understand Kanzi has a point of view, that he has "beliefs and feelings about beliefs and feelings" (Dennett, 1998), then the form and genre of my explanations would not be so tedious and protracted. What justification do humans have in assuming that Kanzi "does not have control over his thoughts" (Donald, 2001) or, worse, does not have a mind of consciousness? The only fact in evidence is that Kanzi's brain is smaller than mine. For if you cannot accept a component of desire, ego, pride, and the "impulse of sheer delight," then you cannot understand Kanzi nor his ability to flake stone tools and use them. Such Cartesianism will ultimately relegate the reader to interpretations of Kanzi's abilities through radical behaviorism. This is a non-informing dead end.

Toth did show Kanzi how to flake stone tools and Kanzi admires Toth, if not loves him. This is notable, for Toth has spent very little time with Kanzi and I am sure has never slept in the colony room with him, cared for him, or nursed him to health in sickness. Yet the mention of Toth coming to the laboratory can get Kanzi so excited. I remember the first time I was present with both of them, I could see in Kanzi's eyes the happiness to see Toth. I did not understand it. A friend explained, "Oh, Kanzi is just excited because he knows when Toth comes he is going to get prestige foods" (anonymous to protect the foolish). However, over the years, I have come to know that this is not true. For the foods Kanzi gets when Toth comes are no different from the ones he can have everyday (Figure 1).

The truth is Kanzi likes Toth. Kanzi respects him. Kanzi's status seems quite elevated in the presence of Toth. But why? Well, Toth is a likable fellow; however, there is something about percussing two stones together which is extremely visual, powerful, and dominant. Toth has prestige, competence, and a silent demeanor which I read as confident and high-ranking - a person who can be in charge and get things done. Bonobos like that, especially in males. Moreover, it is clear that flaking stone to make a sharp edge is transformative. Kanzi knows what a knife is. He knows that a smooth rock cannot cut rope or hide. We have tried it. And to me, there is just a little magic in taking two non-cutting objects and transforming a piece of one into a powerful cutting edge. You know, I am impressed with

Figure 1

Kanzi, the male tool-making bonobo.

Toth myself. I have been flaking stone for about five years, and I am amazed at what Toth can do because my efforts have led to more blood and bruises than works of tools. My feeling is that Kanzi enjoys the feeling of status as much as anyone else and can be a little chauvinistic about it. It seems clear to me that Kanzi has a high level of desire to flake tools because he has an investment in the prestige of the outcome. While it is fun to make and use tools, it also makes you feel good to be able to do something for which everybody admires you, and especially something your sister Panbanisha doesn't seem to do as well as you. Or does she?

Panbanisha, Kanzi's younger sister and the biological mother of my (cultural) bonobo "son," is one of my close friends. We have spent a good deal of time together, and she is the first individual, human or non-human, with whom I ever made rock tools. Our circumstances were somewhat different from the formal expositions of the talent that has made Kanzi so famous. Our efforts to make tools were of a necessity. We were out in the woods one hot summer day, cooling off at Oranges, just past Flatrock (locations within wooded grounds of the LRC). At the Oranges location, metal drums filled with juice and snacks are covered with hide, and the only way to get in the drums is to cut the hide with a knife. The food had been left in the drums from a previous filming episode with Kanzi. The source rocks for making tools, all the good ones, had been removed back to the lab.

We were very hungry and thirsty. We didn't have a knife and there were very few rocks there from which to make tools. Panbanisha and I started looking for cores and cobbles, but all we could find were quartz-like rocks, which I tried to percuss bimanually with those glancing blows. We didn't care if we had thick striking platforms or prominent bulbs of percussion. We were so hungry and thirsty. Sue was no help, she fell asleep snoozing away. I kept trying to produce a flake with a sharp edge, but the substrate was not lending itself to my technique. My hands were bleeding and sore. Panbanisha put her hand on mine and I gave her the rock. She lifted her arm and she slammed the quartz into a large flat rock on the ground, which shattered the rock into lots of sharp pieces. We each grabbed a stone flake, tested it for sharpness, and ran up the hill to cut open the four or five canisters filled with refreshment. They worked just great. We ripped the hide open, got our food, and we didn't cut ourselves. It was some of the best food we ever had. After stuffing ourselves, we were so exhausted from toolmaking we fell asleep. When we awoke, I asked Panbanisha if she liked to flake stone, and she peeped "Yes." I was surprised, because I thought she had no interest in toolmaking or stones. She had appeared to prefer weaving and stringing beads, painting, and grooming. When we got back to lab, I was ready to give her some good rocks the first chance we had.

The following Saturday, Sue was out of town, and Kanzi had gone to P-Suke building. P-Suke, for whom the building is named, was with us at the Main building. He is the biological father of Nyota - a nice, polite, entertaining guy, but wild-caught and raised in captivity in Japan. It is hard to have a conversation with him. He knows how to scream but has no interests in stone toolmaking. If you provide him with rocks, he might hand you one for food, but he does not seem to have any desire to manipulate the rocks. Therefore, he went out to the play yard to eat lettuce while I gave Panbanisha her rocks. These were chert, different from those bad rocks we found at Oranges. Panbanisha seemed to select the rocks she thought were best and sat down on a blanket and began to use bimanual percussion to produce flakes. I was shocked. Where was the throwing technique? In about ten minutes, Panbanisha handed me a large sharp knife and then went to keyboard and uttered, "PINEAPPLE." I got a pineapple and started to cut it with a store bought knife and Panbanisha uttered at the keyboard, "KNIFE." I told her I was using a knife and then it occurred to me to ask, "Do you want me to use the rock knife you made?" She immediately responded and enthusiastically. So I cut the pineapple with Panbanisha's rock knife, and it was a much better knife than those cheap things we have in the kitchen.

The next day, I wanted to capture Panbanisha's two-handed technique on film. Unfortunately, those nice chert rocks were missing and the only ones I could find were those old bad quartz rocks. So I told her I was sorry and gave them to her anyway. Panbanisha looked at her selection for a long time. Then she picked two rocks that I didn't think looked very promising. In the next moment, she stood up and slammed the rocks down unto the hard tile floor shattering the stones everywhere. She looked around at the scattered debris, selected a tool and handed it to me. It was a little knife but Panbanisha thought we could cut "PEACHES" with it. We did, but it didn't last long. My confusion was over her reversion back to the throwing technique, as just the day before she had used bimanual percussion. Well, let me emphasize with embarrassment, my assumption was pejorative with respect to her technique such that I viewed it as qualitatively retrogressive, as you will see.

The next week, Panbanisha, Nyota, Sue and I were out in the woods at Oranges again. This time Sue had the metal drums baited just for us. Apparently, in her sleep the previous visit, she had taken notice of our real time adaptation. Panbanisha and I were looking for rocks from which to make knives. Panbanisha seemed to be digging in the ground. As I looked over at the hole she had dug, she had located a tool flaked on another day which was as useful as the day it was made. I looked to see if there was one for me, and I found one. As we two hungry people ran off with our knives to open the drums, Sue hollered out, "You both cheated!" Panbanisha and I were amused and really did not care,

as we were hot, tired, buggy, and hungry. However, as I laid there resting, I began to think about the various techniques Panbanisha was applying in solving these issues of getting food. What would we do in the wild in real situations? Well, this was real. We were hungry. Our hands hurt. Bugs, spiders, and scorpions had all taken bites out of us. Panbanisha's leg hurt from a fall. My feet had blisters all over them. We were covered with mud and the only food we had was in this forest. It is true our snacks and juice were commercially prepared, but their richness of sugar, fat, and carbohydrate was not available to us without a knife. We had to manufacture a cutting edge or find one. More importantly, we were not even sure what we would find in the metal containers, but we were hungry and in a hurry.

As weeks passed, I began to remember what I already knew: rocks are different and therefore it is reasonable that techniques are different. Efficiency of results is the goal we were seeking. Aesthetics and style? Well, we just did not care. It is delightful to think that Kanzi makes Oldowan tools, but I will tell you, when you are hungry, dirty, bleeding and tired, it does not matter. However, what was clear in reflection is that Panbanisha was evaluating her resources and more authentically utilizing them than I had previously realized. My presumption of a superior knapping technique obscured my ability to see what was really happening. As my false assumptions were washed away, I realized Panbanisha could make tools or scavenge for them. She selected her substrate carefully and applied the techniques that she thought would give the greatest result with the least effort. This meant she could bimanually flake, use the throwing technique invented by her brother, or use an available tool.

In 1999, Roger Lewin, published his 4th addition of Human Evolution: An illustrated Introduction. I always enjoy reading introductory anthropology texts and I was really looking forward to Lewin's new perspectives. He had co-written *Kanzi: The Ape at the Brink of the Human Mind* (1994) with Sue, and Toth was making significant contributions to Lewin's new undergraduate textbook. I felt that the Kanzi research had been perpetually misunderstood and mischaracterized. I was excited that Lewin who knew Kanzi and Toth would be able to adequately inform the truth of the matter; however I was astonished when I read Lewin's quote of William McGrew's theoretical question, "When in human evolution did our ancestors cease behaving like apes?" Then, commenting "In other words, given the opportunity and motivations, could an ape make Oldowan tools?" Lewin reports and interprets Toth's work in this way:

> "Toth had an opportunity to test this experimentally, when he collaborated with Sue Savage-Rumbaugh, of Georgia State University. Savage-Rumbaugh, had spent 10 years working with a male bonobo, Kanzi, who had learned to use a large vocabulary of words displayed on a computerized keyboard and who understood complex spoken English sentences. Toth encouraged Kanzi to make sharp stones flakes in order to gain access to a box that was secured with string. Kanzi was an enthusiastic participating the experiment over a period of several years. Despite being shown the percussion knapping technique, however, he never used it. Sometimes Kanzi produces flakes by knocking cobbles together, but without the precision inherent in the Oldowan technique; often he would simply smash the cobble by throwing it at another hard object, including the floor. Kanzi knew what he needed (sharp flakes) and figured out ways to obtain them (banging or throwing rocks), but he was not an Oldowan tool maker" (Lewin, 1999, pp. 133-134).

My astonishment arises from the fact that I think the tone of this exposition is misleading. First, Kanzi had to cut through a thick cord. It was hardly a string, and therefore, the tool had to be sharp. Second, the research is ongoing and today, Kanzi is 25 years old and Toth and Schick continue to work with Kanzi. I find it curious that Lewin treats the Kanzi research as if the experiment has been completed, and he may interpret the verdict. It seems quite striking that Lewin appears to have completely overlooked the empirical context informing Toth and Schick's investigations, as revealed in the following quote from the first report on Kanzi's toolmaking:

> "Our strategy has been to motivate Kanzi to want a sharp-edged cutting tool (to cut through a cord or membrane to get into a box containing the desired reward), to show him the basic principle of producing sharp stone flakes, and then allow him to work out his own ways of producing his tools from an assortment of rocks provided" (Toth et al., 1993).

Since Kanzi and Panbanisha have both done this, that is, worked out a way of producing sharp-edged stone tools because they want to, exactly what the investigators sought, why jump to judgment? While I do not for a moment support Lewin's hypothesis that Oldowan technologies are a litmus test for 'when our ancestors quit behaving like apes,' I take issue with the inference that undergraduates most likely will assume from this textbook, namely that, based upon the Toth evidence, one may conclude that Kanzi and his kin are biologically incapable of the technical dimension ascribed to Oldowan tools. My objection is the arbitrary and radical line of demarcation between apes and humans in terms of their capabilities.

More recently, Toth and Schick have provided Kanzi and Panbanisha with Gona rocks from Ethiopia. These cobbles are hard and require bimanual percussion to flake. Sue and I have nearly killed ourselves trying to make rock knives with them; however, Kanzi and Panbanisha both make very useful sharp knives with this material. Moreover, they seem to prefer these rocks, which appear to be more suitable for toolmaking.

They are beautiful rocks, the color and size of baked potatoes. They are dense and many of their shapes are easy to hold and are obviously just the hammer you wanted, the ends pointed enough for those glancing blows. Moreover, when these rocks fracture, they seem homogenous and tend to break in more predictable ways. The trade-off, however, is this: it takes a lot of strength and skill to break these rocks efficiently.

Toolmaking with the Gona rocks has been recorded on videotape. Kanzi, from my perspective is a thoughtful and excellent knapper. We are awaiting the interpretation by Toth and Schick of these collections of cobble reductions. The effort has been exciting as Panbanisha has been participating equally with her brother. Well, almost!

One day while filming, Kanzi was busy making his rock tools. He had made some good useful knives and he showed them to me with pride. When it was time for Panbanisha to make some tools, Kanzi went to the middle test room to eat some grapes. We brought Panbanisha out. As usual, she examined her rocks carefully and then began using two hands to make her tool. At first, the effort was anemic compared to what I have observed when she was alone. Then things started to change with a little encouragement from Sue. As Panbanisha progressed with enthusiasm, she started making the sounds that a good knapper makes when flaking success is imminent. At that moment, Kanzi rushed into the Group Room and stopped Panbanisha from making her tool. It became very clear to us that sound was informing how and where the percussion ought to be delivered. Most importantly, however, the sound encouraged us onward, predicting the moment of success! Kanzi seemed very jealous of Panbanisha and Kanzi simply was not going to let her knap anymore. The rest of that afternoon Panbanisha just sort of slapped the rocks together and acted like it was just too hard and she could not do it. I knew better, but it made her older brother happy.

A week later both Schick and Toth visited the lab. Schick, like Toth, is an artist and craftsperson when it comes to stone toolmaking. Schick began knapping. Panbanisha's eyes were as big as saucers. She had only seen Toth make tools. But here was a woman making them too. This really gave Panbanisha the desire to ignore her brother's intimidation, and, from that day forward, she has enthusiastically asserted her right to stone tool manufacture. Interestingly, Kanzi has deferred to her. This is particularly important to Panbanisha's youngest baby Nathan. His attention is most often directed towards what Panbanisha is doing. The experience for Nathan certainly primes the future for his competence in stone toolmaking and use.

The relationship between tools and language seems clear to me. And this is readily observed among the LRC's non-English competent apes' abilities compared with Kanzi, Panbanisha, Nyota, and Nathan. Even with Nyota, who is almost four years old, I have far more success in getting him to make stone tools than I can with P-Suke who is approximately 24 years old. From casual observation it would appear that aside from just the aspect of English as a common medium between Nyota and me, making stone tools just makes more sense to Nyota than it does P-Suke. The bonobos who were not raised by a human language speaker simply organize their communication, culture, and tools in another way, and we are pressed for a common basis of understanding to penetrate the cognitive walls of meaning which different biases erect. However, the most prominent feature of toolmaking is the desire to make them, and while the reward is sometimes food, it is just as often prestige, status, or delight.

Certainly, I have always thought of myself as an Oldowan toolmaker, and I have been confident my tools would be classified as mode I; however, this might be a foolish assumption, and I might have to rethink the characteristics of my tool manufacture. I consider this because, if Kanzi's and Panbanisha's tool sets are not Oldowan, as Lewin claims, then neither are mine. For I cannot tell the difference between a knife I have made and the ones they have made. I must confess my motivation to make stone tools has been about adapting to the challenges that we face; namely, we need a cutting edge that will cut hide or rope. So perhaps our flaking is undirected, and we slap rocks together until we get something that can cut. However, this is counter-intuitive to what happens. Remember, both Kanzi and Panbanisha use different knapping styles at different times with different kinds of rocks. Moreover, there seems to be a melody to the sounds of percussion that guides the flaker to success. It is almost if the stones speak to us as to how and where to strike. That dull low sound means you have to hit harder or find a new spot. As the pitch increases to the sweeter sound, there is a pitch of success which serves as a guiding light to these Pan/Homo stone knappers. Often, the primary attending goal is to produce a cutting edge quickly that we are able to hold easily. While we admire the beauty of our rock knives, we have never sought to contour the style of the knife, but rather its beauty has been in its utility.

Our rules and conventions for tools are quite simple: make a cutting edge that you can hold and that is sharp enough to cut rope or hide. Kanzi, Panbanisha, and I all use our right hand to hold the hammer and it is clear that we all have preferences for certain kinds of hammer stones. This is particularly obvious in Kanzi. While Panbanisha and I will often switch between a hammer stone and cobble, Kanzi demonstrates a marked preference for certain rocks as hammers. When he finds a hammer, he seems to continue to use it as a hammer. In terms of quality and style, our only criteria and motivation is utility. As a rule, we now all use bimanual percussion, Kanzi's throwing technique, and scavenging. It just depends on the substrate and circumstances. Since we have lots of Gona rocks, we are all very proud of our stone tool products and we enjoy the

activity despite the fact we know our hands will bleed and hurt later. We seem to have a singular mindset about what rock tools can do for us and this is based upon the empirical scripts that have been superimposed upon us. We are not a natural population and therefore the pressures and stresses are quiet different. I would argue that as of today, as a rule, creativity and invention do not often play a big part in our straightforward utilitarian toolmaking and use because we have perfected our technique for producing a product appropriate to demands of our Pan/Homo world. For our stone tool technology is a mature one.

However, on one particular day after a lot of toolmaking and filming, Kanzi took one of his rock tools, dare I call it an awl, and he used it to scribe a lexigram upon a metal sheet, just as he uses chalk upon the floor to write and draw. Then he picked up a keyboard and indicated he had written "MILK." This is so typical of Kanzi's inventiveness and is characteristic of his personality. My feeling is that if we were less a laboratory population with more choice and options, faced with real pressures of survival, we would see Kanzi's playful inventiveness directed towards technological expression meeting the challenges of frank survival. However, I might add, if we simply stressed a certain cultural technology, we might observe " . . . mastering the concepts of searching for acute angles on cores . . . and producing acute edged bifacial and poly-facial cores typical of many Oldowan assemblages" (Schick et al., 1999).

But our toolmaking is Pan/Homo, for by design Kanzi was left to his own cultural ways to produce a sharp-edged cutting tool, and his styles have influenced all of us. Today, after years of experience with the bonobos, I am quite certain that we could imitate technology of Oldowan cultures; however, from the Oldowan social perspectives, we are the other. Our adaptation is different because our environment is different. From a postmodernist's view, there is nothing universal about the cultures that produced Oldowan technologies, and therefore, we would not expect them to merely emerge. The absence of Oldowan features in our stone tools is meaningless, unless one assumes that God is broadcasting Oldowan algorithms and you simply have to have the right kind of humanlike brain to access this universal.

From my perspective, both Kanzi and Panbanisha are better rock knappers than I am. They seem to more accurately self-monitor for success and endure longer periods of rehearsal than me. Their expertise is also evidenced in the fact they have fewer wounds from knapping than I do, for we have all not only met the goal of wanting to produce sharp-edged cutting tools, but we can quickly produce them when we need them. I have found Panbanisha, when she is all alone in the play yard, practicing bimanual percussion when she happened to find rocks with which to work. No one was there. She was merely rehearsing and practicing for herself. When she heard me coming, she put the rocks away and attended to me. When I left, she returned to rehearsal with the rocks. This has often suggested a certain level of self consciousness and I believe Panbanisha often practices and performs rehearsals of her activities before she actually tries them in front of cameras and audiences. Whatever emotional interpretation may be applied to her private knapping episodes, I believe it is clear she has a desire to make stone tools and engages in private practice sessions to this end.

Toolmaking and tool use are merely one aspect of the spectrum of competencies that are natural expressions of Kanzi and his family's world. These bonobos are cultural beings who live in a cultural-English-linguistic world, adapting to the stresses and challenges of their world, expressing themselves through the complex opportunities that we offer them and those they create for themselves. Comparative work using Oldowan standards is a useful and interesting exercise when examining the tool expressions of Kanzi and Panbanisha, though their stone tool-related activities constitute just one aspect of their cultural world. It is significant to note that stone tool-making is a craft that Kanzi and Panbanisha have learned as adults; stone tool technologies were not aspects of their ontogeny. They have grown up with modern things such as televisions, VCRs, blenders, mixers, cars, books, computers, and a rich tool-and-gadget set of the information age. Their interests in making stone tools, when they could just as easily have used a store-bought knife, is a choice based in delight, in their involvement and interest in the task at hand. Kanzi's and Panbanisha's only research requirement has been that they have a desire to produce a sharp-edged cutting piece of rock to use as a tool. This is what they have done, and they have done it with finesse.

Kanzi and Panbanisha have acquired their cultural agency and expressions of competency have in much the same manner that human children acquire their language and culture. Paradigms of training, shaping and reinforcement, and arbitrary standards fail to inform the essential truths of these matters. The behaviors of bonobos who employ language and tools and who employ them together deserve an audience of interdisciplinary thinkers who can authentically embrace the discovery they have offered us.

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