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Does Practice Make Perfect? Craft Expertise as a Factor in Aggrandizer Strategies

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Abstract The focus of this article is on exploring craft expertise and its potential as a factor in aggrandizer strategies. It is argued that there are elements of natural aptitude which enabled certain individuals to excel at flintknapping, allowing them to create objects of exceptional size and beauty in acts of elaborate knapping. Practice alone will enable an individual to reach a certain level of proficiency, but only practice in combination with ability can result in world-class performance. If, as is argued, native ability in some domain is a rare commodity, then harnessing it and developing it through practice would provide an opportunity for a potential aggrandizer to control prestige goods and accrue social capital. In situations where raw material, knowledge, and know-how are ubiquitous, as may have been true for flint technology in southern Scandinavia during the Late Neolithic, this might be one of few means available for a would-be aggrandizer to control prestigious goods.

Keywords Flintknappers · Inherited abilities · Practice · Late Neolithic flint daggers

Introduction

Archaeologist Brian Hayden (1995) has proposed an explanation for the mechanisms leading to institutionalized social inequality. Hayden begins with a declaration of his own position, “Self-interest is the ultimate determining force behind human behavior and change”. Further, he maintains that any human population of more than 50 to 100 people will include some ambitious individuals who will aggressively strive to enhance their own self-interest. Hayden calls these aggressive and enterprising individuals, aggrandizers. Aggrandizers are rhetorically skilled. They manipulate other individuals in order to promote their own self-interest and in fact they often act in ways that are contrary to the best short- or long-term interests of the community.

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How do aggrandizers succeed in getting large segments of kin or community to engage in projects which might even be detrimental to them as individuals or families? A large part of the explanation lies in the fact that needs, like values, are not absolute but are a product of culture. Needs can be changed and manipulated to suit the perceived self-interest of community members (Hayden 1995). One such need may be that of possessing a desirable and rare object; a prestige good. The crafted object requiring rare expertise to make may be considered to be such an object. One means for an aggrandizer to gain prestige is if he himself (and aggrandizers are almost always male, according to Hayden) possesses the rare expertise required to make the object, or if he can gain control of a craftsperson who possesses such expertise. The focus of this article is on exploring craft expertise and its potential as a factor in aggrandizer strategies.

We are able to recognize skilled performance in crafts, sport, or art in our own world. In crafting, we evaluate skilled performance by examining the products of performance: objects possessing qualities such as balance, symmetry, clean lines, smooth surface, and fit (Whittaker 1994: p. 181). We apply the same criteria when we wish to evaluate craftsmanship in the results of craft activities in the past. There is also an element of showmanship involved. In contemporary knapping, archaeologist and knapper John Whittaker provides the following colorful description from the Fort Osage knap-in:

> George Eklund, for instance, is one of the most exciting knappers to watch. He often handles large pieces and works very fast, flipping his bifaces up in the air as he turns them over to work on the other face and striking them almost before they are at rest again (Whittaker 1994: p. 117).

Jan Apel has suggested that the final stages of flint dagger manufacture in the Scandinavian Late Neolithic were carried out by master knappers in a public display. Such performance was a vehicle which enabled the knapper fraternity to convey an authoritative message to the viewers, according to Apel (Apel 2001, p. 327; and this volume). When evaluating prehistoric craft performance we are forced to work backwards from the result of performance—the crafted object—to the performance itself—the action of crafting.

An aggrandizer might achieve prestige by controlling a skilled performer: a skilled archer, or a graceful dancer. Or he might do so by getting a skilled craftsperson to make well-crafted objects which can be used as prestige objects in the accruement of social capital. If, however, skilled practitioners in any particular domain are ubiquitous, no such control is possible and there will be no prestige conferred. The questions I am asking here are therefore: (1) are there differences in inherent ability among individuals in the performance of a craft; (2) what is the relationship in skilled performance between inherent ability and learned capacities; and (3) is craft expertise a rare commodity? The empirical basis is the Late Neolithic of southern Scandinavia.

I propose to examine the question from the perspective of contemporary performers. I will first discuss the results of a survey of contemporary knappers which I carried out in the 1990s (Olausson 1998). The survey, designed to elucidate whether contemporary knappers possessed natural abilities which may make them especially suitable craft practitioners, yielded ambiguous results. Therefore, I turned to contemporary studies of skills in other performance fields, such as playing a musical instrument and learning a sport, to look for more persuasive arguments in favor of the existence of inherent ability in performance. I then examine the relationship between natural ability and practice in skilled performance, and conclude by applying these results to prehistoric knapping. Three pairs of concepts are important for my reasoning; I begin by presenting these below.

Skill and Ability

Following terminology in the behavioral sciences I will use the term “skill” to denote actions which can be learned and improved with practice (Roux 1990; Starkes *et al*. 1994). I use “ability” to denote inherited talents or proficiencies. High ability in this case means that an individual has an aptitude for learning to perform. A central question in this article is to what extent ability affects the level of skill attainable by any given individual.

Knowledge and Know-How

Archaeologist and knapper Jacques Pelegrin is credited with introducing the concepts of knowledge (*connaissances*) and know-how (*savoire-faires*) into the archaeological discourse (Pelegrin 1990). According to this paradigm, knowledge is situated in the mind and is explicit and declarative, while know-how is experiential and learned by doing (Apel 2001: pp. 27–28; Apel 2006). Knowledge is abstract and can be transferred by means of words, while know-how is physical and can only be acquired by doing.

Ordinary Production and Elaborate Knapping

Pelegrin, an accomplished knapper himself, has suggested that two levels of lithic production can be found in many prehistoric contexts. He calls these two levels *ordinary production* and *elaborate knapping*. Analysis of stone age production, as well as his own experimental work, has convinced Pelegrin that a suitably larger flint nodule and a little more patience are not sufficient for achieving the levels required for elaborate production—say the successful manufacture of blades 30–40 cm long. This requires a much higher level of know-how (Pelegrin 1990). I believe this is an important distinction which may help us to understand the prehistoric situation as well. Below, I will argue that elaborate knapping can only be carried out by the most expert performers. The result is what we call prestige items.

Late Neolithic Flint Daggers

During the Late Neolithic in Scandinavia (2350–1800 cal B.C.), flintknapping reached an apogee with the production of bifacial flint daggers (Stafford 1998). Bifacial tool types were numerous in the Late Neolithic and, besides daggers, they included sickles, spear points and various projectile points. Of these, daggers are the tool type which shows the greatest variety of morphological subtypes (Fig. 1). From a knapper's point of view, each dagger subtype presents problems of greater or lesser severity, but all types involve a high width to thickness ratio, symmetry, and controlled pressure retouch. Some contemporary knappers hold that the type IV dagger is the most difficult to master (Apel 2001; Callahan 2006), while others claim that type IC is the most difficult (Stafford 2003). Type IV combines a thin blade with a triangular handle, parallel pressure retouch on the blade and pressure retouching on the handle, whereas the difficulty in making the best examples of type IC lies in their notable length and the consistency of the pressure flaking (Stafford 2003; cf. Nunn 2006).

Scandinavia lacks sources of tin and oxidic copper ore. Nevertheless, it appears that metal held some attraction since imported copper objects appear in the archaeological material from the late Mesolithic period and throughout the Neolithic (Klassen 2000). However, it is not until the Late Neolithic that metallurgy, in the form of casting, occurs within the Scandinavian area (Vandkilde 1996, 2005). Thus, the Late Neolithic period in Scandinavia is a time of social tension between the old order, based on natively available raw materials, and the new, based on imported metals. Some consider Late Neolithic society to be undifferentiated, while others suggest that the hierarchy visible in the Bronze Age is already underway at this time

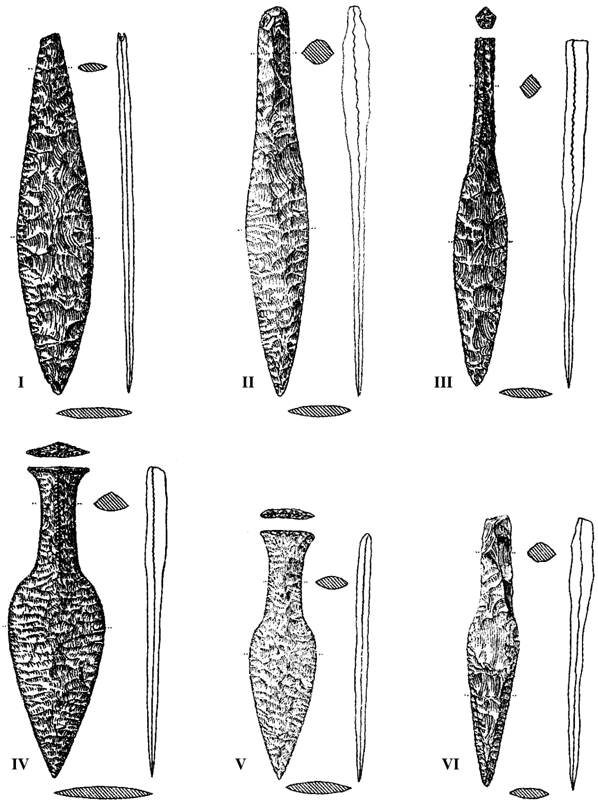

Fig. 1 The six main types of Late Neolithic flint daggers, as defined by Lomborg (reprinted from Apel 2006, with permission).

(Apel 2001; Lekberg 2002; Vandkilde 1996). Thus, the Late Neolithic would seem to be a particularly apt period in which to search for aggrandizers.

Explaining Quality Differences on Daggers-is it Possible?

Several observations about the flint daggers are pertinent to the question of prestige items. Daggers are numerous and geographically widespread. The most comprehensive and up-to-date registration of flint daggers has been published by archaeologist Jan Apel (2001; and this volume, Table I), who lists a total of 13,168 daggers. Those who have studied flint daggers have noted that they show a wide range of knapping quality. I conducted a study of a random selection of *c.* 540 flint daggers of all types from the collections at the Historical Museum in Lund. I recorded knapping quality on a scale from "poor" to "excellent". Some daggers are exceptionally well-made and symmetrical, while others are poorly made and show large numbers of knapping errors. Poor and medium quality knapped daggers outnumber well-made examples in all of the types except for type IV, and type IV daggers are less numerous than other types (Fig. 2; Olausson 2000; cf. Callahan 2006; see also Fig. 5). These observations, coupled with other evidence, suggest to me that flint daggers are not a class of objects controlled by any aggrandizing individual or group. It is possible, however, that the best examples of each type were a product of skilled performance carried out under the control of an aggrandizer. In a situation in which neither know-how, knowledge, nor raw material is controllable, skilled craft performance based on

Fig. 2 Late Neolithic type III flint daggers from southern Scandinavia showing the range of differences in knapping quality. (Bengt Almgren, Historical Museum, Lund)

inherent ability, practice, or a combination of these factors, may be one of the few factors a would-be aggrandizer could control (Olausson 2000). Thus:

1. If inherent differences in knapper ability do exist, an aggrandizer can exploit them by sponsoring talented individuals as attached specialists (Brumfiel and Earle 1987).
2. If knapping skill can be improved by practice, an aggrandizer can sponsor an individual, enabling him or her to raise performance levels.
3. If a combination of natural ability and practice leads to the highest performance levels, an aggrandizer will gain the greatest advantage by finding a talented individual and providing him or her with time to improve through practice.

Were we able to witness prehistoric crafting performance directly we might be able to distinguish between skilled performance and unskilled performance, but we would still not know to what extent ability and/or practice lay behind each. The same dilemma presents itself if we propose to use the *products* of craft performance in such an investigation. There are at least four possible explanations for the differences in knapping quality I observed on the Late Neolithic daggers.

1. Strategic or situational. A poorly made dagger may have been manufactured by someone who was capable of making a perfect type IV dagger but for some reason did not use his/her skills to the utmost. Constraints of time or lack of cultural incentive for any given knapping situation are possible reasons for this attitude. For example, during the historic period in the American Southwest, skilled potters in the Hopi area made small crude vessels as offerings for clay sources. This is an example of a "realm of protected deviation", a culturally defined circumstance in which crudely made vessels were considered acceptable (Crown 2002: p. 113). Capacities which are not realized in material culture will simply not be visible to us. As Thomas Wynn wryly remarked "there is no way logically to eliminate the possibility that prehistoric Einsteins were making crude stone tools while speculating about general relativity" (Wynn 1993: p. 33).
2. Apprenticeship. Poorly knapped daggers may be failed or practice pieces made by an inexperienced knapper who was on his/her way to reaching top-level skills (Apel 2001). We should beware of the "finished artefact fallacy"; i.e., the belief that the final form of flaked stone artifacts as found by archaeologists was the intended shape of a "tool" (Davidson and Noble 1993: p. 365). The waste products and rejects from flintknapping, practice pieces as well as "proper" pieces, are generally not reusable and therefore they remain in the archaeological record. In investigations of pottery production in the Prehispanic American Southwest, archaeologists Patricia L. Crown and Elizabeth A. Bagwell dealt with examples of pottery vessels which demonstrated errors or clumsiness in manufacture and/or decoration. In spite of these flaws, the vessels had been fired and many showed use-wear. Crown and Bagwell argue that many of these vessels were made by children engaged in learning pottery making; nevertheless they were fired and used (Bagwell 2002; Crown 2002).
3. Differences in inherent ability. The poorly crafted dagger may have been the best the knapper could produce, even after practice. I can envision a situation in

which every Late Neolithic dagger maker was "aiming" for an end product of the highest quality. Different abilities meant that he or she was unable to realize the template.

4. Constraints set by the raw material. Clearly, there is a relationship between raw material tractability and knapper skill. A well-proportioned dagger made from an inferior raw material is evidence of a greater level of skill than a comparable dagger made from a more easily worked material. Systematic studies comparing raw material qualities from the knapper's point of view are needed so that we can assess the impact of this factor with greater accuracy (Crabtree 1967; Högberg and Olausson 2007; Finlay, this volume).

Archaeological evidence alone is inadequate for choosing between these alternative explanations for knapping quality. Our only remotely direct means of insight into prehistoric levels of skill and/or ability is through the physical results of the crafting performance, and unfortunately we cannot follow any individual prehistoric flintknapper's development through time. Instead, we must rely on more indirect sources of information. I propose two avenues of approach to investigate the question of the role of abilities. The first is by surveying contemporary flintknappers. The second avenue is an evaluation of research in contemporary performance fields such as music and sports.

Contemporary Flintknappers

Finding little published information about differences in inherent ability among knappers when I first thought about this in 1995, I devised a simple questionnaire to try to explore characteristics which may be indicative of inherent abilities among modern knappers. Initially, I mailed the questionnaire to 359 knappers whose names appeared on a list of addresses compiled in 1986 (Atwood and Harwood 1986). Questionnaires were also mailed to the knappers I know and administered to a group of beginning knappers attending a weekend course near Lund. I received 126 replies from these (a 28% response rate). I also published the questionnaire in the newsletters *Chips* (ed. D.C. Waldorf) and *Flintknapper's Exchange* (ed. Charles Spear). The total survey results reported here were based on 197 replies, mainly from American knappers. A shorter version of the questionnaire was administered to first- and second-term archaeology students at the University of Lund in order to gain a comparative population of non-knappers. Fifty-eight students replied to this questionnaire.

My survey work was carried out over a period from 1995 to 1997 and the results were published in an article in *Lithic Technology* in 1998 (Olausson 1998). American knapper and archaeologist John Whittaker conducted a knapper survey at about the same time, as part of his ethnographic study of American knappers. His respondents were 90 Fort Osage knappers and 70 others (Whittaker 1994: p. 13).

The aim of my survey was to answer the following questions. What qualities make up a good knapper? Are there inherent attributes (physical and/or mental) that enable some individuals to reach a level of proficiency which those who lack these qualities can never attain? In addition to direct questions about knapping, I posed questions about sports preferences, musical abilities, and chess playing skills (cf. Olausson 1998 for details).

It is important to point out that in at least three important respects the modern knapper population cannot be assumed to be representative of the prehistoric knapper population. One obvious difference is what Clark (1986) calls the “Crabtree caveat”. By this he means that contemporary knappers rarely master any one technique to the degree that some of their prehistoric counterparts did. Modern knappers do not restrict themselves to any single knapping tradition, but tend to try out many techniques and to replicate pieces from varied temporal and spatial contexts (Whittaker 1994). A second difference is that most modern knappers have had less exposure to knapping from childhood than their prehistoric counterparts.

In one final and important respect I think modern knappers are not representative of prehistoric knappers. Survey responses indicated that most contemporary knappers see themselves primarily as artists rather than “mere” craftspeople. Whittaker’s extensive ethnographic study of American flintknappers emphasized that the vast majority of knappers today view their activity as an “art” (Whittaker 1994: p. 171). Using Pelegrin’s terminology, contemporary knappers are striving for elaborate knapping, not ordinary production. I will return to the importance of this factor below.

Spatial Intelligence is Important for Flintknappers

High responses on the survey to questions about artistic abilities and the ability to draw three-dimensional objects confirmed that spatial abilities are important qualities in contemporary knappers. Psychologist Howard Gardner (1994) writes that spatial intelligence involves such things as perceiving an object’s place in its surroundings, the ability to see small differences in details, and the ability to recognize patterns. Gardner says that spatial intelligence is especially important for sculptors and chess players. Simon and Gilmartin (cited in Anderson 1990: p. 282) estimate that chess masters have acquired mental catalogues of 50,000 different chess patterns and they can quickly recognize such patterns on a chessboard. Anthropologists Charles and Janet Keller, writing about blacksmithing, cite the importance of imagery and visualization in all craftwork (Keller and Keller 1996: p. 132).

Flintknapping is a process which requires cooperation between our intellectual and our motor abilities and it is dependent on good spatial intelligence. That is, the successful knapper must be able to envision the three-dimensional product as well as the general sequence of stages leading to it. Flintknapper Payson D. Sheets notes that because the chipped-stone industry is fundamentally a subtractive one, considerable planning is necessary to arrive at the desired end product (Sheets 1975). Each step in the knapping process should logically lead to the next; thinking ahead is therefore essential (Whittaker 1994: p. 135). Knapping requires the cooperation of both hemispheres of our brains as well as good spatial abilities (Stout *et al.* 2000).

From Knowledge to Know-How: The Importance of Manual Dexterity

> I see the blade or point in the stone as a kind of mental 'print'. The rest is removing the stone using different approaches till the point is released (Anonymous in Olausson 1998: p. 106).

However, the ability to envision the desired product is not sufficient for making it: the knapper must also be able to translate the mental blueprint into a practical outcome (Bril *et al*. 2005: p. 70; Roux and David 2005: p. 101). The knapping process involves constant interplay between the knapper's brain and his or her motor skills (Karlin and Julien 1994; Pelegrin 1990).

The site of Trollesgave, a Late Glacial settlement found on southern Zealand in Denmark, provides a prehistoric example in which this link was undeveloped. Among the debitage, Anders Fischer found two nodules of high quality flint which had been clumsily worked. These contrasted to the rest of the debitage, which showed good control and efficient use of the raw material. Fischer could ascertain that the knapping techniques used on the poorly-worked nodules were in principle the same as those used by the master knapper at the site. In practice, however, the execution of the techniques differed. Fischer likened the degree of manual control shown on these two nodules to what is achieved by schoolchildren in their initial attempts at learning to write. The apprentice knapper apparently had a mental picture of what to strive for but lacked the manual skills to realize this picture. That is, he or she may have had the required knowledge but lacked the necessary know-how (Fischer 1990; see also Högberg, this volume).

In the knapper survey, ball sports and shooting sports, both of which require good hand-eye coordination coupled with practice, accounted for 63% of sports choices among contemporary knappers. Many knappers work at technical or craft professions requiring manual skills. Among those who practice art, 44% preferred sculptural media. Almost as many, 41%, preferred drawing or painting. Whittaker's survey revealed that quite a few knappers also practice other crafts, ranging from painting and sculpture to wood-carving and blacksmithing (Whittaker 1994: pp. 143–144). These data indicate a link between knapping propensity and abilities such as hand-eye coordination and manual dexterity.

Calvin's description of what happens when we throw darts applies to flintknapping kinematics as well:

> Your arm is an unguided muscle shortly after the throw has begun. So you must plan perfectly as you get set - create a chain of muscle commands, all ready to be executed in the right order (Calvin 1993: p. 234).

In a Position Emission Tomography (PET) study of what areas of the brain are activated during knapping, Stout *et al*. (2000) found that the pattern of activation in the brain is that which would be expected for a complex motor task requiring hand-eye coordination.

Pelegrin claims that becoming adept at percussion techniques requires both natural talent and intensive practice (i.e., both ability and skill). Because percussion movements are so rapid they cannot be controlled by vision, they must rely on prior practical experience in order to be successful (Pelegrin 1990: p. 118). Several questionnaire respondents pointed out that good hand-eye coordination is an advantage when knapping. One knapper said that although flintknapping is a learned skill, certain inherent abilities enable one to excel in biface thinning where touch is necessary and innate hand-eye coordination an advantage (Anonymous, in Olausson 1998).

Survey results suggest some areas in which inherent abilities might influence craft results. I propose now to attempt to reach a more persuasive conclusion in support of the existence of natural ability in knapping by examining results from other disciplines, such as sports psychology and cognitive science, in which we can study performance.

Inherent Ability in Performance

Heated debate among behavioral scientists makes it clear that, while the majority would cast a vote for some genetic component to skill acquisition, we have not yet reached consensus on the existence of inherent ability (Howe *et al.* 1998). The clearest exposition in defense of inherent ability which I have been able to find comes from a book about coaching written by three sports psychologists following a seminar at the United States Olympic Training Center in 1986. In regard to inherited ability they write:

> Everyone has ability. Some have great cognitive abilities, while others have significant musical or artistic abilities. Others may have great motoric or athletic abilities. While we each may have varying degrees of ability in certain areas, few if any have great abilities in all areas. We must also realize that ability is inherited (Vernacchia *et al.*1992: p. 18).

Psychologists Robert Singer and Christopher Janelle suggest that situations and individual genetic differences have to work together in order for the most ideal outcomes to occur. Genetic factors may mediate response to practice. Those individuals who find themselves with talent may be motivated to practice more than others, providing positive reinforcement. In their article they conclude:

> Emerging evidence from genetic studies is beginning to show clear distinctions between not only the physiological, but also the biomechanical, morphological, and psychological differences between expert and non-expert sport performances (Singer and Janelle 1999: p. 146)

Sports psychologist Benjamin Lowe, in *The Beauty of Sport*, regards skilled sports performance as a form of art. He presents a study by Leonard Koppett called *All about Baseball*. Koppett identifies four major attributes of pitching greatness in baseball: “stuff”, control, craft, and poise. “Stuff” is a slang expression meaning the physical element: how hard the pitcher can throw, for instance. Koppett argues for inherent ability: *Stuff is the product of strength and exceptional hairtrigger coordination, and seems to be an innate quality, perhaps improvable by practice and technique, but not acquirable* (Koppett 1967: p. 308).

A concept which I find useful when discussing inherent abilities is that of psychologist Howard Gardner’s seven intelligences (1994). Gardner criticizes the dominant Western view of a single intelligence as measured by classical IQ tests.

Instead, he suggests that humans possess at least seven domain-specific types of intelligence including linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, and two kinds of personal intelligence. In support of his position Gardner uses evidence from a variety of sources:

- there are separate neural centers underlying these various intelligences,
- there are individuals who are exceptionally talented in just one of these dimensions,
- there are separate developmental histories for each,
- there are cross-cultural universals in the display of such abilities, and
- distinct symbol systems have emerged for each.

On the question of the existence of inherited ability Gardner is cautious, however. He says human intelligences or intellectual capacities are part of our nature and he mentions talent as a helpful factor in learning a skill. He also says that learning a skill is a combination of external stimulus, constant experimentation, and basic prerequisites in the nervous system which make it possible to develop certain structures.

Hatano (1998), Plomin (1998) and Detterman *et al.* (1998) agree that heritability has an impact on the learning and performance of motor tasks, while Gagné (1998) adds that ease of learning (an inherited ability) is *the* hallmark of natural abilities. This produces speed of learning, which gives rise to precocious achievements.

Turning to the knapping domain, knapper and archaeologist Errett Callahan has written of his experience with teaching biface reduction to 350 university students over a seven-year period. The students grasped the simplest reduction strategy in two hours. The next phase, flaking to the median line so as to cover the entire surface of a biface with flake scars, could be learned in four to eight hours. As early as this second phase, however, Callahan writes that he observed differences in ability. He noted that some students could achieve success within the first session (with considerable instruction), while others might fail to master it in a semester (Callahan 1979; see also Ferguson, this volume).

By now my position on this question should be clear: I maintain that individuals do differ in their inherited abilities. Even though I have only been able to hint at which abilities are most beneficial for knapping, I believe that differential inherited ability is a factor in determining knapper prowess.

Returning to the knapper survey, several respondents noted an element of inherent ability as an asset to knapping competence; for instance: “I teach stone-age skills on weekends. Very few students ever become proficient;” or "I think everyone can knap, but like all talents, because of natural inborn talents some are more adept than others" (Anonymous, in Olausson 1998: p. 107).

Ability + Practice = Expert Performance

Wright has shown that an orangutan can be taught to make flakes (Wright 1972), but “years of practice have not allowed even the most highly trained, ‘enculturated’ modern apes to equal the abilities seen in the earliest hominin stone tool makers” (Stout and Chaminade 2007). Thus, if we accept that there is an element of natural ability involved in performance, the next step is to ask what bearing this may have on the role played by practice in the acquisition of a skill.

Archaeologist Dietrich Stout and neurologist Thierry Chaminade (2007) have conducted research to determine if practice affects brain activity. They carried out an experimental study in which they studied functional brain imaging data from six inexperienced subjects while they were learning to make very simple chipped stone artifacts. Subjects participated in one pre-practice and four post-practice tool making sessions. Although they were given no instructions or practical demonstrations regarding appropriate tool making techniques, all six succeeded in producing simple flake tools in the sessions.

Following practice, the subjects showed increased activity in those areas of the brain that contribute to the visual control of action and the perception of objects. Activation in these areas likely reflects increased attention to locating and identifying properties which are technologically relevant for knapping. Further, results suggested that practice resulted in a functional reorganization in the brain. Stout and Chaminade's conclusion is that the most basic level of skill acquisition is concerned with perceptual-motor adaptation to task constraints rather than with executive planning and problem-solving. They conclude, "...the acquisition of such sensimotor capabilities clearly depends upon a combination of neural preconditions with motivated and effortful practice.." (Stout and Chaminade 2007: p. 1098).

When addressing the question about the effects of practice on performance, I believe it is necessary to return to the distinction between ordinary production and elaborate knapping, corresponding to the concepts of ordinary performance and expert performance in the behavioral sciences. Looking at this question in terms of behavioral science, K. Anders Ericsson states that we need to distinguish between expert performance and everyday actions as being two qualitatively different things. He suggests that there is a difference in cognitive abilities required for these actions. In everyday activities, most individuals strive for effortless execution in which actions become automatic (such as when we have learned to write or to drive a car). As soon as we have attained an acceptable level of performance, the process of automation begins, thereby prematurely arresting further development. Experts, in contrast, maintain the ability (and the motivation) to control and monitor their performance and to improve it. The major difference between everyday performance and expert performance is in the motivational factors that lead a small number of individuals to maintain their effortful pursuit of their best performance (Ericsson 1998).

We can distinguish three hypothetical positions on the question of the relationship between ability and practice in the expert performance of any motor activity:

1. Expert performance is due to practice alone.
2. Expert performance is due to inherent ability alone.
3. Expert performance is due to a combination of inherent ability and practice. Only those individuals possessing both will reach the highest levels of performance.

As partial support of the first proposition I can cite an unpublished study of contemporary knappers by archaeologist John E. Clark (1986), who postulated a direct relationship between knapping skill and time spent knapping. Hypothetically he saw no limit to the level of skill a knapper can reach, although time constraints mean that in practice each craftsman will reach a plateau of skill dictated by his or her annual production.

However, archaeologist Dietrich Stout (2002) provides a relevant ethnographic example which refutes the first position. In his study of adze-making among the Langda of New Guinea, he found that seven men were actively involved in adze-making: three acknowledged experts, three apprentices, and one older man who was recognized by the society at large as an established craftsman. Having been part of the adze-making community for many years, the older individual must have had the advantages of long training. If practice alone were sufficient he should have reached the level of expert. However, Stout was surprised to note that this person performed at a lower level than his peers; in fact, Stout found that this individual had the same pattern of performance as the apprentice knappers. Stout says he is unsure as to whether this is because of declining skill due to age or to a lack of innate ability. In any case, the individual would seem to be an argument against the first position.

The power law of practice, which says that practice will increase the speed at which a task is performed (Anderson 1990), also provides partial support for the first position. Experiments have shown that speed increases rapidly at first, then more slowly (Fig. 3). This is a commonsense proposition which most of us would support based on our own experience. However, the power law of practice is vague about whether there are any limits to improvement. Psychologist John Anderson (1990) notes that limits to how much improvement can be achieved are determined by the capability of musculature, age, level of motivation, etc. Therefore the idea that practice alone will enable an individual to reach the highest performance levels seems untenable. Most authors agree that extensive practice is a *necessary but not sufficient* condition for the development of skilled performance in any field.

The vast majority maintain that expert performance requires both ability and practice, position three. Speaking against position two and in favor of position three, Vernacchia and colleagues state:

> ...while having a lot of ability certainly enhances a person's opportunities to achieve in specific areas or activities, ability alone does not guarantee the attainment of succes. Just being talented isn't enough, but rather how one develops and uses his or her talents will determine the level of success which is achieved...Having talent and ability is one thing. Being able to utilize one's

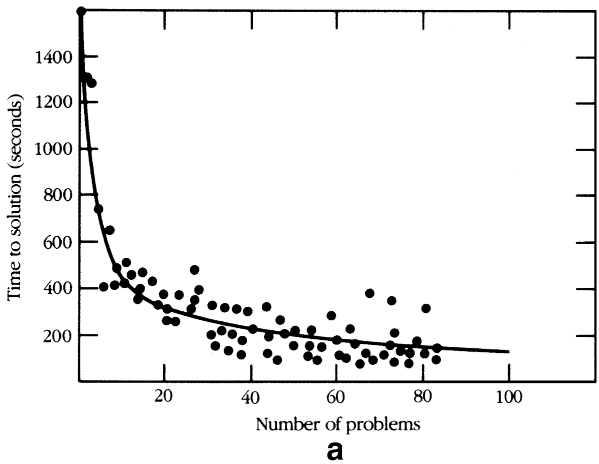

Fig. 3 The power law as illustrated by a learning curve showing time to generate proofs as a function of the number of proofs already done. Speed of improvement is rapid at first (reprinted from Anderson 1990, with permission).

> ability most effectively and efficiently is something altogether different. This occurs only after the committed investment of oneself in planned and purposeful preparation...(Vernacchia *et al*. 1992: pp. 18–19).

An archaeological example can be found at the Upper Paleolithic site of Etoilles, in the Paris basin. Etoilles has been interpreted as a site for obtaining and processing raw material (Karlin and Julien 1994: p. 159). Nicole Pigeot, an archaeologist who has studied the debitage and carried out refitting, speculates that the 25 elaborate debitage clusters at Etoilles represent one or more knapping specialists whose knowledge or know-how surpassed that of the average adult in Magdalenian society. Further, she claims that the high level of technical skills shown on these refitted nodules indicates unusual ability (Pigeot 1990). If Pigeot is correct in her assumption that the highest knapping level seen at Etiolles could not have been reached by all Magdalenians, then presumably not all of the apprentice knappers would have been able to attain that level, even with the instruction they seem to have been given at Etiolles (Fig. 4).

In fact, most of us would probably find ourselves supporting the third position, although understandably there is a great deal of disagreement about the relative importance of ability and practice to the final outcome (Rowe 1998; Schneider 1998; Thomas and Thomas 1994). Joan Freeman expresses the relationship between ability and practice well when she states: "although dedicated effort might be essential for world-class performance, it cannot by itself produce [such performance]" (Freeman 1998: p. 415). Practice is necessary for expert performance, but beyond a certain point the absence of talent looms larger and larger, say behavioral scientists Feldman and Katzir (1998). Perhaps the most telling evidence to suggest that practice alone is not sufficient for high performance levels has been offered by psychologist, Aidan P. Moran (1996). He notes that the relationship between hours of experience and expertise in some domains (e.g., chess performance) is not linear. Some chess players fail to progress in either performance level or ranking despite gaining increased experience of this game (Moran 1996).

My conclusion is that the highest levels of expert performance will only be reached by individuals having the benefits of *both* inherent ability *and* long practice.

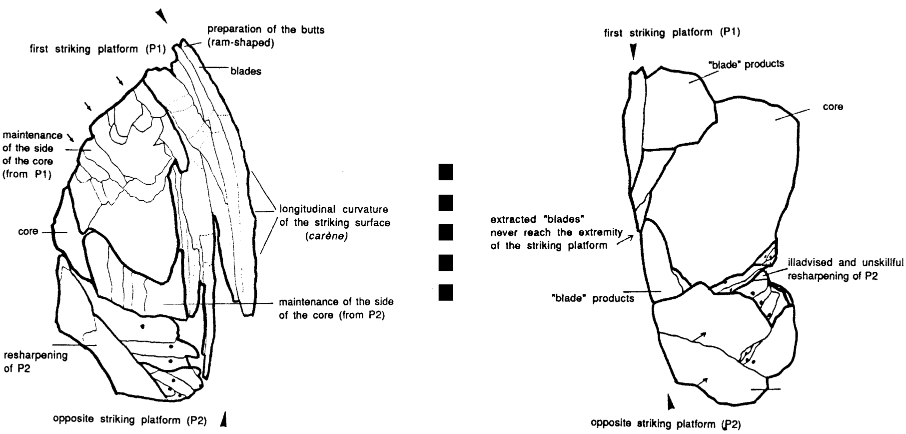

Fig. 4 Nodules worked by expert (*left*) and unskilled (*right*) knappers at Etoilles, as defined by Nicole Pigeot (based on Pigeot 1990, with permission).

For the would-be aggrandizer, therefore, the name of the game is to be able to recognize individuals of high natural ability and to sponsor them so that they can practice (Olausson, 2007). Spotting ability is tricky but not impossible. Stout's Langda study provides one example (Stout 2002). Adzes are produced by a semi-hereditary all-male community of craftsmen who have developed their skills over a long period of time under the tutelage of their elders. Entry into the community occurs through a period of apprenticeship that can last up to five years or longer, and only close relatives are invited to join. The master evaluates the seriousness and commitment of a potential apprentice. He makes some attempt to evaluate natural aptitude as well, since masters judge early attempts at knapping before deciding to accept an apprentice. The fact that masters look at potential apprentices' early attempts at knapping suggests to me that masters believe they can spot individuals with natural ability before offering them formal training.

Archaeologist Barbro Santillo Frizell provides another ethnographic example of talent-spotting. Her study focuses on the craftsmen who build the traditional so-called *trullo* roofs in southern Italy. Trullo-building skills are passed on within the family from generation to generation. However, even given the same training and legitimate peripheral participation, not all children in a family become masters at the craft. The subject Santillo Frizell interviewed emphasized that it was important that children have talent for the work. According to him, it was possible to distinguish promising candidates at an early age, and the master's ability to see this was itself recognized as a skill which could not easily be described in words (Santillo Frizell 2000).

Tool Behavior as Sequence Construction

In the preceding text I have argued that, in flintknapping as well as other performance fields, the combination of inherent ability and practice is necessary for expert performance/elaborate knapping. Venturing even deeper into this thicket, I now propose to explore the question of whether there are aspects of performance which are amenable to practice, while others are more reliant on natural ability. To explore this question I find it helpful to refer to anthropologist Thomas Wynn's article "Layers of thinking in tool behavior" (1993). Wynn speaks of tool behavior as a system in three layers: (1) biomechanics, (2) sequence construction, and (3) constellations of knowledge. The lowest level is that of *biomechanics*, which consists of the constraints imposed by the anatomy and physiology of the tool-users. These constraints include the amount of force that can be delivered and the scale of precision. For instance, low body strength may place physical limits on the length of pressure flakes an individual can remove (Ferguson 2003; and this vol.).

Wynn calls the second layer *sequence construction*. He maintains that tool behavior is sequential. It consists of motor actions strung together into episodes usually terminated by a recognizable final result, the completed task or artifact. The novice first learns tasks by serial memorization and has no clear idea of how each action relates to others or, indeed, how they combine to accomplish the result. After beginning to master some of the tasks, novices assemble smaller tasks into larger complexes of action.

Because tool sequences are organized like strings of beads and learned by observation and repetition, apprenticeship is essential to the learning of tool-use and tool-making. Every individual learns a tool sequence by constructing his or her own string of beads through repetition and rote memorization. Significantly, Wynn uses the example of instrumental musicians, who employ this technique in learning passages of music. This level requires practice, whereby basic actions and sequences are repeated until they have been learned at a very primitive cognitive level and they become more or less automatic. Acquired or declarative knowledge is thereby transformed into know-how or procedural knowledge (Anderson 1990; Moran 1996).

This process involves primarily what Gardner (1994) calls bodily-kinesthetic intelligence. Many actions which we carry out are performed so quickly that there is no time for feedback from perception. Therefore we pre-program whole sequences of intensively trained, automatic, skilled and occasionally involuntary actions. These require only minor adjustments based on information from the senses when they are carried out (Gardner 1994: p. 194-95).

In an example from the world of knapping, archaeologists Valentine Roux and Eva David describe how apprentices learn to knap carnelian beads in India. Teaching this skill never involves methods or courses of action, but rather concentrates on techniques for different types of flake removal for making beads. This skill can only be acquired through repeated practice over one to two years. Once each type of removal is perfected, the apprentice moves on to another. Further, sequences are not necessarily learned in the order they will be applied in the completed *chaîne opértoire*. For instance, the removals necessary for making roughouts are always learned *after* those for making performs, probably because the latter require greater motor control (Roux and David 2005: p. 102).

Stone tool making requires several abilities, among them: evaluating cobble composition and morphology, choosing an appropriate target for the blow, using efficient postures and holding patterns, planning and executing accurate percussion (Stout and Chaminade 2007). In flintknapping, the speed of many of the actions means that learning individual sequences must occur by sequence construction (Biryukova *et al.* 2005: p. 88). The following quote from Don Crabtree illustrates this very well:

> Technological evaluation is based, in part, on understanding the muscular motor habits and the rythmic removal of flakes. After the rough material has been reduced to a stage where the worker can repetitiously remove a series of flakes from the margin, the mind, eye and muscular responses often develop a rhythmic and subconscious reaction to applying the force. Experience and habit eventually cause the worker's muscles to respond subconsciously to induced forces (Crabtree 1972: p. 3).

Here I would say we are at the level of skills which can be learned and improved with practice. Contemporary master knapper Jacque Pelegrin gives the following advice to novice knappers (in Callahan 1981: p. 69):

> I think there are some steps. You first have one movement under control, not too many but one controlled movement. Try to make some good flakes with hammerstones, controlling them completely.

An archaeological example which supports the idea that knapping is learned by mastering discrete units of tool sequences can be found at the Upper Paleolithic site of Pincevent in the Paris basin. The site appears to have been chosen for its strategic position along the seasonal migration routes of reindeer. At least two types of flintknapping strategies are evident here: one characterized by standardized and well-controlled production, and one which is driven by immediate needs. Standardized production requires a high degree of skill, and refitting has shown that many of the products of standardized production have been removed from the site, presumably curated. But archaeologists also found blocks which appear to have been worked by less skilled knappers on the site. Many of these blocks are of inferior raw material and there is an absence of any selection of items for use. Knapping patterns on these indicate that knappers were exercising basic principles. Karlin and Julien (1994: p. 162) suggest that these blocks are pieces made by apprentices during practice.

Finally, Wynn refers to the highest level of tool behavior as *constellations of knowledge*. Biomechanics and sequence construction do not fully explain the complexities of tool behavior. In mammals, at least, tool behavior also entails problem-solving and the ability to adjust behavior to a specific task at hand. Constellations of knowledge are not learned by rote memorization. Rather, they come into existence at the time of use. The elements involved are determined by the task at hand, especially by the visual images the artisan has of his or her goal.

Since every knapping situation is also unique, the process is by no means simply mechanical. Archaeologist and knapper Mark Edmonds emphasizes that choice is also part of flintknapping. The artisan is capable of implementing a number of different strategies to create a particular artifact (Edmonds 1990). The knapper therefore constantly evaluates the current situation and chooses, from the methods at his or her disposal, the one which is preferable and possible, a decision which implies continuous mental assessment of possible consequences (Karlin and Julien 1994; Schlanger 1994).

Based on their experiments with carnelian bead-making, Roux and David see the dynamic involving interaction between functional movements, perceptual information and planning as the most important determinant of knapping expertise. Expertise lies in the regulation of the elementary movements; the strings of beads (Roux and David 2005: p. 104). The elements in such constellations are quite varied and they include, according to Wynn (1993), aesthetic, stylistic, and functional standards. At this level I believe we begin to enter the area in which natural ability or talent may affect the outcome of the task. Let us see if Wynn's ideas are applicable to the prehistoric knapping situation.

The Artistry of Elaborate Knapping

In *The Beauty of Sport*, sports psychologist Benjamin Lowe (1977) equates skilled performance in sports with skilled performance in other domains which we usually associate with art, such as dance or painting. He proposes that the same qualities are necessary for the highest levels of performance in any of these domains.

> The efforts of the elite athlete, the high-level performer, the 'superstar', demonstrate man's aspiration to the highest standards of physical endeavor, and out of these efforts come elemental features which we can describe as beautiful (Lowe 1977: p. 227).

Following Wynn, I believe that constellations of knowledge involve an aesthetic element as well as an ability to successfully translate an idea into a practical outcome. Aesthetic considerations seem to be involved in what we have called elaborate knapping or, in other terms, prestige technology. In support of such an idea I can quote archaeologist Kenneth Oakley:

> The artistic impulse appears to have manifested itself in exceptional individuals long before the Upper Paleolithic period, indeed probably from the dawn of tool-making. The great Acheulian hand-axe...from the gravels at Furze Platt, Maidenhead, is evidently the product of an artistic craftsman (Oakley 1961: p. 127).

There is no mistaking that many contemporary knappers are striving for beauty in their products. One survey comment which can serve to illustrate the reponses was as follows:

> I think the artistic types definitely lean towards knapping and usually the more artistic they are the better their work is. I've seen this in a lot of people. Also the artistically inclined people pick up flintknapping much faster (Anonymous, in Olausson 1998: p. 109).

A number of survey respondents commented on an apparent correlation between knapping and creativity and the survey revealed that the majority of knappers consider themselves artistic. Whittaker results confirmed this; the majority of contemporary knappers regard knapping as an art (Whittaker 1994: p. 171).

David Pye, a former architect, industrial designer and craftsman, defined craftsmanship as workmanship in which the quality of the result is not predetermined but depends on the judgement, dexterity, and care which the maker exercises as he works. Pye says that in true craftsmanship, the quality of the result is continuously at risk during the process of making (Pye 1968). The best knappers, then, are those who have mastered constellations of knowledge to such an extent that they are not hampered by flint's limitations. Anthropologist Tim Ingold says the novice becomes skilled not through the acquisition of roles and representations, but at the point where he or she is able to *dispense* with them (Ingold 1993: p. 462). Because of his extraordinary competence, Callahan can choose to make a dagger which is larger than any prehistoric example. Alternatively, he can choose to demonstrate his competence by following a prehistoric template as closely as possible, showing his control of the medium in this way instead (Callahan 1984, 2006).

Anthropologist William Davenport describes an ethnographic example which I suggest is analogous to the prehistoric situation, at least in regard to flintknapping in Late Neolithic Scandinavia. On the Pacific island of Aoriki, the talents of artisans are viewed as rare skills. The artist, as opposed to the artisan, is someone who is exceptional in all the skills that competent men and women should possess, plus a few others. At the highest level of proficiency are the men who can build trading canoes. The individual who possesses all the talents required to build these canoes is considered a master craftsman, an artist, an exceptional person. Further, exceptional talents are considered to rely partly on inspiration and assistance from tutelary deities. Thus, in every truly great work of art on Aoriki there is a connection with the supernatural, an element of the spiritual. The utilization of exceptional aesthetic skills is confined to objects used only in rituals (Davenport 1986).

Fig. 5 The Late Neolithic type IV dagger found at Hindsgavl, Denmark (Danish National Museum, Copenhagen).

The dichotomy between ordinary production and elaborate knapping is significant and I believe it can help us understand the south Scandinavian Neolithic. When the knapper's aim is to make a stone tool which will enable him or her to put food on the table, practical considerations are likely to be paramount over aesthetic ones (although perhaps the best knappers do not need to choose between these aspects). Here, the ordinary knapping skills which all individuals could learn would suffice. However, when making an elaborate type IV dagger, expert knapping skills as well as high ability are called for. The best knappers, both today and in the past, would have needed an aesthetic sensitivity as well as good motor skills to be able to realize this in flint. This combination is rare among individuals and it is one which an aggrandizer could exploit to his advantage.

Conclusions

The question of whether all individuals are capable of reaching high levels of flintknapping competence has proven difficult to answer on any empirical basis. John Whittaker writes:

> Flintknapping requires no unusual strength or artistic abilities to learn the basics. Anyone with normal intelligence and hand-eye coordination can make ordinary stone tools with a little practice. In most stone-age societies, knapping was probably a skill everyone had (Whittaker 1994: p. 2).

Whittaker and I agree (Whittaker, personal communication) that while ordinary knapping was a competence which all adult members of the stone age population would have to learn, just as in our culture we are all expected to learn the motor skills required for the act of writing, there is also evidence of expert performance in prehistory just as there is today. There are many examples of typologically similar prehistoric artifacts with quality differences which are due to differences in knapper expertise. Since being able to make functional tools was crucial for survival, most group members had to be trained in the techniques necessary to make everyday items. However, I maintain that there are elements of natural aptitude which enabled certain individuals to excel at flintknapping, allowing them to create objects of exceptional size and beauty in acts of elaborate knapping. Practice alone will enable an individual to reach a certain level of proficiency, but only practice in combination with ability can result in world-class performance-an individual capable of making a Hindsgavl dagger (Fig. 5). If, as I maintain, unusual native ability in some domain (i.e. one of Gardner's intelligences) is a rare commodity, then harnessing it and developing it through practice would provide an opportunity for a potential aggrandizer to control prestige goods and accrue social capital. In this situation, the aggrandizer who wishes to control the well-crafted piece may do so by controlling the skilled craft performer. In situations where raw material, knowledge, and know-how are ubiquitous, as may have been true for Late Neolithic flint technology, this might be one of few means available for a would-be aggrandizer to control prestigious goods.

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