Weapon Trials: The Atlatl and Experiments in Hunting Technology

John Whittaker

Grinnell College, Grinnell, IA 50112

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One of my favorite bits of archaeological jargon is the description of stone projectile points as part of "complex projectile delivery systems" (Christenson 1986). While I am amused at the formality of the words and the image of a little man in blue ringing your doorbell with an arrowhead, the point behind the verbiage is important. Most archaeological analyses of hunting technology work with orts and morts, fragmentary remains of relatively complicated composite tools. The most common survivors are imperishable stone components. Meanwhile, hunting has held a consistent fascination for many anthropologists, as a dramatic and "manly" occupation with considerable symbolic baggage in our own culture. One complication in the archaeological study of hunting is that modern hunting technology is often far removed from that of the past. Most modern hunters find "primitive" technology quite alien, and in order to understand the functioning and capabilities of past hunting gear, experiments with pre-industrial weaponry have been fairly common (Knecht 1997).

In this paper I focus on the atlatl or spearthrower, with a historical slant, as it is important to show how experimentation responds to the archaeological problems of its time. The atlatl is essentially a stick with a hook or socket to engage the spear on one end and a grip for the hand on the other end (Figure 1). It allows you to throw a spear considerably harder and farther than by hand alone. This projectile technology was common throughout prehistory, antedating the bow and arrow. It is well-known ethnographically, and like archery, is experiencing a revival in the form of recreational sport. The archaeological evidence shows some of the same problems of sampling and interpretation visible in the archaeology of all hunting, and experiments with atlatls illustrate both the potentials and the difficulties of such work. Because there existed much less historical record and tradition for atlatls than for bows, and because there were fewer ethnographic examples, experiment played arguably an even larger part in the archaeology of the atlatl. Experiments with spear thrower technology offer lessons that apply to most archaeological experimentation.

Ethnographic beginnings

In the 19th century, ethnographers became aware of a projectile system quite different from the bow and arrow. Early explorers in the Arctic and Australia observed spears cast with the aid of a “throwing stick,” “spear thrower,” or “throwing board.” A typical account is that of Charles Darwin (1909:457), traveling on the Beagle in 1836, near Bathhurst, Australia.

> At sunset a party of a score of the black aborigines passed by, each carrying, in their accustomed manner, a bundle of spears and other weapons. By giving the leading man a shilling, they were easily detained, and threw their spears for my amusement… In their own arts they are admirable. A cap being fixed at thirty yards distance, they transfixed it with a spear, delivered by the throwing-stick with the rapidity of an arrow from the bow of a practised archer.

It was not long before casual observation led to more focused scholarly interest. In the Arctic Otis Mason (1885) was one of the first to describe Eskimo “throwing sticks” and the distribution of different types. He explained their use alongside bows and arrows by citing the difficulty of using a bow in a kayak with wet and greasy hands. Murdoch (1892) described in more detail the "hand board" or "throwing board" and the spears used in one area around Point Barrow in northern Alaska, and correctly explained the motion. Nelson (1899) reported in similar detail on the gear used in western Alaska, and was impressed by the "considerable accuracy and force from 30-50 yards" with which seal spears were thrown.

In Australia, spear throwers were described more or less briefly by many ethnographers (e.g. Roth 1909; Spencer and Gillen 1938; Haddon 1912). Davidson (1936) classified forms and examined their distribution (Figure 2). Krause (1905) included Australian material in a survey of "spear slings" around the world.

Early Archaeology

According to Lansac (2001, 2004), French archaeologists Lartet and Christy made the first archaeological finds of spear throwers at Laugerie-Basse in 1862, although it was not until 1891 that de Mortillet recognized them from analogy to Australian spear throwers. In the Americas, archaeological interest in spear throwers seems to begin with Zelia Nuttal (1891) who surveyed the Mesoamerican codices, sculpture, Spanish historical records, and three extant specimens to describe the Mesoamerican atlatl. She had a particular interest in iconographic and linguistic evidence for spear throwers and their symbolism. Otis Mason (1893) was the first to claim an archaeological specimen, recognizing that a southwestern Basketmaker artifact collected by the Wetherills and displayed at the World Columbian Exhibition was equivalent to the atlatls described by

Nuttal and the Eskimo throwing sticks with which he was already familiar. Nuttal and Mason are apparently responsible for the dominance of the term atlatl in America. The eccentric genius Frank Cushing was immediately interested, and worked various forms of atlatl and other less plausible devices into an evolutionary scheme leading to bows and arrows (1895). He claimed his reproduction of the cliff dweller atlatl worked, which may make him the first atlatl experimenter on record. He soon recognized other atlatl forms among the wooden artifacts from his excavations in the Florida Keys (Cushing 1897; Gilliland 1975).

The archaeological problems which still influence atlatl studies developed early, and all led to experimentation. They can be grouped under three headings: 1) The relationship of spear throwers to the bow and arrow. 2) The recognition of atlatls in the archaeological record, a) from projectile point evidence and b) from atlatl parts themselves, especially stone weights or bannerstones. 3) The functioning mechanics and capabilities of atlatls.

The relationship of spear throwers to the bow and arrow

In the early days of professional anthropology and archaeology, theoretical attention focused on issues of technological chronology and the distribution of cultural traits. The question of whether the atlatl was earlier than the bow was primarily a question of archaeological chronology, obscured somewhat by the observation that atlatls and bows were used contemporaneously at least among some Mesoamerican and Arctic cultures.

Cushing (1895) immediately accepted that the atlatl was earlier than the bow, apparently because it suited his evolutionary ideas. He proposed a sequence starting with various weakly documented devices derived from classical accounts of augmenting javelin throws with cordage. The flexible atlatl of the Basketmakers then followed, and led to a couple of hybrids that he called the "spear-crook or flinging bow" and the "bow-crotch." The former is a speculation based on Zuni prayer sticks: by adding a string across the crook of some prayer sticks, you get a gadget that might be used as an atlatl with the added springing action of the bow-like part. The bow-crotch seems even more far-fetched. However, Cushing felt that these hypothetical artifacts could lead logically to the bow proper. Perhaps I should not ridicule the spear-crook, or the unfortunately named bow-crotch, as neither has had a fair experimental trial, but Cushing's whole scheme was based on the mistaken assumption that it was the flex of the atlatl that supplied the power and inspired further inventions leading to bows.

Others who accepted the primacy of the spear thrower over the bow may have done so just because it seemed a simpler invention (J.A. Mason 1928), or on the basis of very limited evidence that atlatls were found in contexts that lacked bows, and appeared to be earlier, as in the southwest US (Pepper 1905). However, even the southwestern chronological evidence was not securely documented for some years (Kidder and Guernsey 1919; Baker and Kidder 1937; Fenenga and Wheat 1940). Similarly, in Paleolithic Europe, the carved antler objects eventually recognized as spear throwers were seen to appear earlier than any evidence of the bow and arrow (Garrod 1955; J. A. Mason 1928), and in Australia, considered isolated and primitive by early anthropologists, the bow and arrow never did supplant the spear thrower.

Any evolutionary relationship between atlatl and bow remains speculative, and to my mind, unlikely. As we will see, atlatls and bows work by completely different principles, not by a common use of the power of a flexing spring, although many people still make that mistake in trying to explain the sequence of inventions (e.g. Farmer 1994; Kjelgard 1951; Lyons 2004; Perkins 2000b). Pretty much everyone now agrees that the atlatl was earlier. However, the timing of the introduction of the bow remains a very live controversy, in the Old World (Lansac 2004), and especially in the Americas. This is largely because the hard evidence for both atlatl and bow is sparse.

Archaeological recognition

Atlatls and bows are mostly made of perishable materials, and it is remarkable that we have as many prehistoric specimens as we do. Once archaeologists recognized the existence and basic form of spear throwing devices, dry contexts in the American west produced a number of good specimens, and Cushing's wet finds in Florida a few more, and there are a number from frozen Arctic deposits (Diters 1977). Spear throwers are older in the Old World, and less well preserved, but the cave sites of France yielded bone and antler objects eventually recognized as spear throwers, or more correctly, as parts of spear throwers (Garrod 1955; Stodiek 1992, 1993). All told, I can find references to more than 60 partial and complete atlatls from the Americas now, not counting hooks and weights. (For extensive atlatl bibliographies, consult Whittaker 2004a; Bruchert 2000). There are at least a dozen extant atlatls from late prehistoric and contact period Mesoamerica (Saville 1925), and many from South America, less well published. Garrod (1955), Chavaux (2003), and Stodiek (1993) have information on 66 or so specimens from Europe. These are mostly the antler or bone hook portion, which is sometimes elaborately decorated and a familiar part of the corpus of Upper Paleolithic "art." Lansac (2001), following Cattelain (1988), lists 118 specimens. I have been unable to find published archaeological atlatls from the rest of the world. One might expect Australia, with dry climates and a long prehistoric record, to have produced examples, but the prehistory of hunting equipment there is known mostly from rock art (Morwood 2002:164). The basis for reconstruction and experimentation with spear throwers is thus based on archaeological specimens from Europe, mostly France, and the New World, mostly North America, augmented by the ethnographic and ethnohistoric examples from the Arctic, Australia, New Guinea, South America, Mexico, and elsewhere.

Early archaeologists interested in the chronology and distribution of atlatls in the Americas were hampered by their fragility, and to this day the difficulty of recognizing both bow and atlatl by fragments or associated artifacts continues to lead to arguments. Projectile points are the commonest evidence cited in attempts to date the arrival of the bow and arrow or recognize the presence of different types of projectile weapons. The usual expectation was proposed long ago (e.g. Baker and Kidder 1937, Kidder 1938), most explicitly by Fenenga (1953). The bow propels a lighter projectile than the spear thrower, so the heads of arrows should be much lighter than those on darts used with spear throwers, or spears thrown by hand. However, some early experiments were performed precisely to address this idea. Browne (1938, 1940) tested both bows and atlatls, and argued that large points worked perfectly well on arrows. He contended that Baker and Kidder should not expect the bow to be late; in fact, Folsom points were perfect arrowheads. It is plain from Browne's own words that his atlatl gear or his skill with it was not good enough to make this evaluation. "Any close degree of accuracy is impossible with atlatl and spear," he said, admitting that after 6 months practice he still could not “hit a buffalo 1 out of 10 times at 30 yards." To a modern atlatlist this seems laughable; to a prehistoric hunter it would be pitiable. Whatever the deficiencies of Browne’s experiments, his argument about the allowable variation in point size is supported by other experiments (e.g. Couch et al. 1999). Ironically, while most archaeologists believe that Folsom and Clovis points were probably used with spear throwers (Frison 1989; Ahler and Geib 2000; Tankersley 2002), hard evidence for early Paleoindian atlatls has been hard to find. Hutchings (1997) argues that point fractures show high-velocity impact, implying atlatl use, and Hemmings (2004) identifies ivory hooks from Florida rivers as Clovis atlatl parts. Similarly, although no one doubts that small late points tipped arrows and large early points should have armed atlatl darts, it is still risky to use point size to identify the early arrival of bows (Bachechi et al. 1997**;** Bettinger and Eerkens 1999; Geib and Bungart 1989; Hughes 1998; Nassaney and Pyle 1999; Silva 1999; Webster 1980) or the late retention of atlatls (Lorentzen 1993). There have been numerous attempts to pin down the differences between points by examining ethnographic and archaeological material (Corliss 1980; Shott 1993, 1997; Thomas 1978), and most of the articles cited use more sophisticated arguments than point size alone, but the basic difficulty of recognition remains. The situation is exactly similar in Europe (Lansac 2004).

Even recent work with Yukon ice patch artifacts, where more or less complete projectiles can be examined and a fairly clear-cut transition date provided (Gotthardt et al. 1999; Hare et al. 2004) found a couple of surprisingly ambiguous artifacts whose form or dates do not fit well with the other evidence.

It would seem that parts of actual spear throwers would be less controversial than the points, which are only indirectly connected as parts of the “complex projectile delivery system,” but this is not the case. Finds in the southeast US ignited a series of arguments that continue to this day. Clarence Moore (1916), reporting on a series of excavations along the Green River in Kentucky, led off his entire monograph with a discussion of the problem of “bannerstones.” The class of artifacts known as bannerstones was familiar enough to need no definition in Moore’s work. They are stone objects, drilled lengthwise, having a variety of forms tubular to triangular in cross section, sometimes with “wings” or other elaboration, and often finely made of hard and colorful stone. The name used by collectors and archaeologists reflected a general belief that they had no “practical” use and were objects of ritual or display.

Moore noted that at the Archaic shell mound of Indian Knoll, bannerstones often were found associated in graves with antler objects of similarly tubular form, and with antler tine hooks. He argued that the hooks were for making netting, with the bannerstones being sizers to gauge the mesh, and cited some ethnographic parallels. However, Moore noted that a Mr. Charles Willoughby, associated with the Harvard Peabody Museum, had suggested that the hooks might be the distal end of throwing sticks. This suggestion had enough force that Moore spent a page refuting it on the grounds that 1) there was no evidence of throwing sticks from that region, 2) throwing sticks are usually one piece artifacts, for strength, 3) small points of antler or flint were not associated, 4) some of the hooks are too crooked for atlatls and some have holes too small to attach them firmly, and 5) if the hooks are atlatl parts, that still leaves the stone and antler objects with them unexplained. Points one and two seem quaint today for their assumption of complete archaeological and ethnological knowledge, and disregard for the problems of preservation. Three seems odd since Moore reported plentiful "arrow" points in his sites, including some that pierced bones. He probably meant that while hooks and "sizers" were commonly found together, points had not been found in the same graves. As Doucette (2001) has noted, his burial excavations did not necessarily encompass the further edges of the grave, where points on shafts might have been found. However, with points 4 and 5 we are finally getting to the realm of experiment, since even in Moore's day, experiments to determine the function and capabilities of artifacts were common. In fact, Moore had his steamboat captain make a section of net using wooden models of a hook and "sizer," and concluded that this was the likeliest function of the sets from graves (Moore 1916: 433). It was left to Webb and others to carry the argument into the modern era of experimentation, demonstrating that hooks and bannerstones do work as atlatl parts, with the bannerstones serving as weights. Currently, most would agree that the antler hooks and similar items elsewhere were atlatl parts, although some atlatl hooks may not be so readily recognized.

The issue of bannerstones, however, is far from finished, although most archaeologists consider them atlatl weights. Webb's experiments were initially aimed at archaeological recognition of atlatls at Indian knoll; they were intended to show that bannerstones worked as atlatl parts. However, they soon involved him in more complex issues, so we will return to bannerstones as we discuss the different goals and results of experimentation with atlatls.

Function and Capabilities of Atlatls

The mainstream of spear thrower experimentation has been directed at understanding the capabilities of atlatls, and how they function. These connect to some of the earlier issues of archaeological recognition.

How does an atlatl work?

Our knowledge of how to throw a light spear with an atlatl, both theoretical and practical, comes from both ethnographic observation and practical experience. There are three main models, which typically arose almost as soon as archaeologists began trying to understand spear throwers. We can refer to these as the lever action, extended force, and flexing spring models. Some of these models are based more on physics theory than on physical experiment. I will concentrate my attention on experiments to resolve the questions of physics.

1) Lever Action. The atlatl is most correctly described as a lever, or rather a complex series of levers. The sequence of motions visible on slow-motion film (Whittaker and Hilton 2003) and described by others (Cundy 1989; Vanderhoek 1998) is as follows (Figure 3): With the dart raised level to the ground and aimed at the target, the atlatlist begins by stepping forward, which brings body, arm, and dart forward. As the step is completed, the torso rotates and the throwing arm flexes at the shoulder, bringing the hand and atlatl forward. The atlatl stays level and the dart on target throughout this motion. To complete the throw, the wrist flexes violently, swinging the atlatl up to vertical and flicking the dart away. Finally the arm and body follow through as the dart

flies toward the target. The motion is essentially the same as in throwing a rock or a baseball, with the difference being the atlatl. By flexing the wrist rapidly a small distance, the distal end of the atlatl moves a much greater distance, acting as a lever to impart energy to the dart (Baugh 2003). Cundy (1989) analyzed 1970 ethnographic films to arrive at the same sequence, and notes that this sequence of motions allows slow, powerful muscles to act first, followed by the less powerful but faster actions, producing a smooth and efficient acceleration. Most of the gain in velocity is from the wrist and atlatl motion in the last 1/10 second of the throw (Cundy 1989, see also Hutchings and Bruchert 1997). Most atlatl experimenters agree that the lever model is the correct one (Butler 1975), as did some early observers (Murdoch 1892).

2) Extended Force. Howard (1974) gives the most extensive discussion of how an atlatl might function by extending the time force is applied to the dart, although the idea was not new with him (eg. Krause 1905; Mason 1885). As Howard describes it, “the atlatl is not a catapult or flipping device. During a proper throw, the spur reaches no greater elevation than that of the handle.” He believed that the hook on a level atlatl simply remains in contact and delivering thrust longer than a hand throwing the same spear with a similar motion. Moreover, flipping the dart with a lever action of the atlatl will not work because (1974) “hooking results when the thrower fails to keep the atlatl level during the thrust,” and because (1976) the atlatl hook would break off under the stress of a dart rotating on it.

It surprises me that this model received any credence at all, since plenty of ethnographic photos show atlatls swung up to vertical as the spear departs, as do increasing numbers of photos of modern experimentation and sport use (Whittaker and

Hilton 2003). Any atlatlist who expects to throw with force for any distance knows that the flipping motion is important. However, a number of authorities apparently still adhere to at least parts of this model (e.g. Raymond 1986; Vanderhoek 1998). Experiments and personal experience suggest a reason. Keeping the atlatl level through the throw will work for short throws (Vanderhoek 1998). However, it is very poor form with most light darts, and in training myself, I found it was a bad habit I had to overcome before I could throw effectively at any distance. Also, the hand can remain at about the same height for most of the throw, dropping down at the end, as the atlatl is flipped. I would additionally guess that with a heavy, relatively inflexible dart such as some Arctic harpoons, keeping the atlatl level may be the proper way to throw them, but someone needs to experiment explicitly and report on this issue.

3) Flexing Springs. But what about the flex of the atlatl, mentioned earlier, and also the flex of the dart, which is dramatically visible in so many photos? A number of atlatlists, most vocally Bob Perkins (Perkins 1995, 2000a, 2000b; Perkins and Leininger 1989), argue that as the atlatl pushes against the rear of the dart, both dart and atlatl flex, storing energy which then springs the dart forth from the atlatl, contributing a large part of its velocity. Baugh's (1998; 2003) mathematical modeling suggests that gains of 7-12% might be possible with a flexible atlatl. Webb (1957) proposed a somewhat more complex version. He believed that the flex of the atlatl, combined with a "bannerstone" weight that through time was placed closer and closer to the hook end of the atlatl, served to "transfer momentum" to the projectile, just as the elasticity of a ball and bat transfers energy to the ball.

There are a number of arguments against the flexing spring model. First, the majority of ethnographic spear throwers are rigid or nearly so, so flexibility of the atlatl is not necessary. Webb, Baugh, and the others admit this, but argue that a flexing atlatl is more efficient. Most importantly, high speed photography shows that the atlatl does flex during a throw, but is still flexed after the dart has departed, having no time to spring back and add to the dart's velocity (Whittaker, Maginniss, and Hilton 2005). The spring issue is complicated by the fact that the projectile unquestionably flexes, sometimes a great deal, and inflexible darts are almost completely unusable, but this is not because the springing action stores useful energy. As the atlatl is raised at the end of the throw, while the dart is kept aimed at the target, the nock end of the dart must rise with the atlatl, flexing the dart. This does store a certain amount of energy, but it is mostly released as latitudinal oscillations of the dart (Baugh 1998; Cundy 1989). Finally, Webb's model of "transferring momentum" to the dart is incorrect. The atlatl increases dart velocity as explained in the "lever action" model. Adding weight to the end of the atlatl near the hook slows down the throw, and requires more force in flexing the wrist. A number of atlatlists have tried atlatls with bannerstones near the hook, and some swear by them (Lyons 2002). I find them extremely clumsy and slow, and physical principles show that they must decrease the efficiency of the throw (Baugh 2003; Cundy 1989).

Atlatl Motion Experiments

Many descriptions of how an atlatl works come from observations of ethnographic (Cundy 1989) atlatl users or modern experiments done for other purposes, and often rely heavily on a theoretical model from physics (Butler 1975; Cotterell and

Kaminga 1990). Stop action or slow motion photography has only begun to be exploited (Cundy 1989; Hutchings and Bruchert 1997; Stodiek 1993; Whittaker and Hilton 2003; Whittaker, Maginnis, and Hilton 2005) and it is now possible to do much more sophisticated motion studies, so this is an area where future experimentation will soon improve our understanding of the physics and human motion, and allow better control of variables in controlled experiments.

Experiments with weights

The issues of bannerstones and the role of weights on spear throwers have produced more experimentation than any other part of atlatl studies, although such artifacts are limited to parts of North America. As usual, there are several theories about the use of weights on atlatls, some irreconcilable, others allowing a degree of overlap. Most experiments with weighted atlatls attempt to measure changes in efficiency, or at least maximum throwing distance. As we will see, this is the easiest variable to measure, but accuracy at short range was probably more important to prehistoric hunters.

The oldest idea of course is that bannerstones had no practical use at all. Many early writers agreed with Moorehead (1910:410) that “It has always seemed to me ridiculous to claim that the prehistoric peoples made use of objects, on which a great deal of time and hard labor were spent, for ordinary purposes.” Like Baer (1921) and others, they assumed that fragile, exotic, and un-sharpened objects could only have been “mounted on handles for ceremonial use,” or hung around the neck as ornaments. The supposed fragility of bannerstones bothers a lot of people, but is of course easily testable. My experience, and that of many others, including Webb (1957), is that they are perfectly strong enough to serve as atlatl weights. Peets (1959) even used the edge of a winged bannerstone as the hook on his atlatl. Similarly, successful atlatls can be constructed of multiple pieces, including wooden shafts thin enough to pass through the drilled hole in most bannerstones, so the doubts of Moore (1901) and others (Hothem 1998) on that matter can be laid to rest. Even now, the dominant view among those who are interested in bannerstones rather than atlatls favors the idea that bannerstones were largely decorative or ceremonial, even if they were sometimes attached to atlatls (Knoblock 1939) or may even have originated as atlatl weights (Lutz 2000). Looked at the other way around, as Kwas (1982) and others (Mau 1963; Precourt 1973; Webb 1957; Winters 1968) have pointed out, it should not be surprising that functional objects attached to important weapons might have high intrinsic and symbolic value. The consistent association of complete atlatls in the SW and hooks, handles, or both in the SE with stone objects makes a good contextual argument for the weight theory (Webb 1946; 1957; Drass and Brooks 1984; Doucette 2001).

But why would you want to attach a weight to an atlatl anyway? The concept of stone atlatl weights originated with the southwestern finds of relatively small stones attached to some Basketmaker atlatls, although Cushing (1895) and others (Guernsey 1931) emphasized their importance as charms. Webb seems to have been the most vehement proponent of the atlatl weight theory. He felt that the weight transferred momentum to the projectile, increasing the force and distance of the throw, a theory which makes no physical sense. A number of experiments have attempted to test the effect of adding weights to atlatls. Summarizing a few of them shows the diversity of opinions and also some problems of experimental design and comparability that will be emphasized later.

Webb (1957) theorized a lot, and the implication of his reconstructions is that he tried them out, but nowhere does he report experimental results. Hill (1948) tried two different atlatls with and without small weights near the handle, throwing three different spears, with arched and flat throws. He measured distance for 6 throws for each of the resulting 12 trials, and concluded that weights were negative or useless. Mau (1963) without expressing a theory of how weights work, reported that a moderate weight close to the handle of the atlatl increased the distance of his throws by 15-25%. However, although his experiments were interesting, he tested several variables and did not report in enough detail to determine whether there is any statistical significance to his results. Palter (1976) believed that weight would augment the flex of an atlatl, but noted that tests were contradictory; his own showed distance to decrease as more weight was added. Details of his experiments were not given, but his graph shows 10 throws with each of 5 weights (0-450 gms) attached at an unstated distance from the atlatl grip – hardly a large sample. Peets (1960) found no significant difference between weighted and unweighted atlatls, but never stated what weight he used or how many throws he made. He did note that his angle of 40 degrees of elevation for distance throws was probably not consistent. Howard (1974) also found no benefit from weights, based on a sample of 18 throws, presumably using the atlatl incorrectly as described earlier.

Like Palter (1976), Hayes (1994) and Perkins (1993) believe that adding a weight to an atlatl influences the flex. Perkins says that the weight acts as resistance, like the projectile itself, to flex the atlatl and store energy, and Hayes argues that it is necessary to "tune" the flex of the atlatl to the flex of the dart. As far as I know, no one has experimented systematically with atlatl flex or the effects of weights on it, but my own work has convinced me that atlatl flex does not affect dart velocity (Whittaker, Maginniss, and Hilton 2005).

Another popular theory is that the weight on a spearthrower serves as a balance to steady the spear when it is aimed or at rest (Peets 1960; Elliott 1989, Cundy 1989). Hobbs (1963) attempted to get the best of both worlds by designing a bizarre atlatl that incorporated a bannerstone that slid along a central rod, so that it provided balance at rest, but during a throw slid out to the end of the atlatl, apparently following Webb's model of increasing momentum. He concluded from his experiments (details not reported) that any atlatl provided twice the throwing distance of a spear thrown by hand, and his "super atlatl" did even better, up to 55 yards. I have not tried such a gizmo, but suspect it would be highly inefficient.

Physical principles (Cundy 1989; Baugh 2003) show that a weight on an atlatl will usually slow it down, increasingly so as the weight is nearer the tip, but Cundy, Vanderhoek (1998) and others argue that a weight can provide steadying inertia, reducing the tendency to sway the atlatl out of line during a throw. Weighting would then be intended to improve accuracy, rather than distance. Accuracy is probably the variable most of interest to prehistoric atlatl users, but I know of no experiments along these lines.

Perkins (1993) believes that not only does a weight affect atlatl flex, but some winged bannerstones act as "silencers" to reduce the swishing noise of a throw. He claims that sound recordings of experimental throws support this theory.

Others have suggested functions for bannerstones that are tangentially or not at all related to atlatls. They could be spindles on a drill (Parker 1917), or for spinning cordage (Bruchert 1996). Bob Berg, (in Leeth 2004), wants to explain the association of bannerstones with atlatl parts as burial of the spindle needed to make cordage for hafting as part of a set with the atlatl. Net weaving has been discussed, and again, experiments showed that it is possible to weave a net with antler hooks and bannerstone sizers. Parker (1917) suggested that a bannerstone could work as fletching on a spear, and Cole (1972) also put the bannerstone on the spear. He argued that it would have no effect on the atlatl, but on a spear, a bannerstone could serve as a balancing weight that would slide down the shaft at impact, hammering the spear deeper. Both these ideas are implausible to the Nth degree, and a nice example of why actually trying a tool improves real understanding.

Weapon trials: Problems with experimental evaluations of atlatls

Obviously, to understand prehistoric weapons, we must make evaluations of their efficiency and utility for different tasks. A number of experiments have shown that atlatl-thrown projectiles can be deadly. Most notably, Frison (1989) experimented with the carcasses of culled elephants to demonstrate that a Clovis point on a spear hurled with the aid of an atlatl could make a killing wound in even the largest of animals, which are not called pachyderms for nothing. Other archaeologists have also shot dead elephants (Butler 1980; Callahan 1994), or smaller animals or carcasses (Cattelain 1997; Flenniken 1985), and there are many other unpublished experiments of varying quality. Bruce Bradley informs me that he and others killed a bison with atlatls, and François Bordes once told me that as a boy he “threw a spear right through” his neighbor’s dog after it killed his cat. The legal and social complications of this last anecdote make it a poor model. Although atlatls are not currently legal for hunting in most states except in private game parks and for taking some “nuisance” game, there are numerous reports from the sport atlatl community of deer, boar, and fish taken with atlatls (Becker 1992, 2001; Berg 1996, 2002, 2003; Fogelman and Berg 1998; Hutchings and Bruchert 1997).

None of this should be surprising. After all, atlatls were used all over the world for thousands of years, so they must have worked well. The real problem for modern experimental archaeology is deciding how well they worked in comparison to other weapons, and comparing the different forms of atlatl. However, comparisons are difficult in the absence of any standard (Whittaker 2004b). Which prehistoric atlatl is being compared to what? For that matter, does the replica or reconstruction of a prehistoric atlatl reliably replicate the important features of the prehistoric model? It is not hard to use the correct materials, and to copy weight, dimensions, and flex of complete specimens, such as those from the prehistoric Southwest, or Australian ethnographic examples, but forms that have only been partially preserved, like the finds from Indian Knoll or Key Marco are open to some interpretation (Figure 4). A combination of practical experience and experiment with the archaeological evidence can get us pretty close, but remember, the atlatl itself is no more a complete “projectile delivery system” than the stone point. With the possible exception of some burial sets from South America, I do not know of any archaeological cases where the atlatl and the darts to be used with it are both preserved. Ethnographic sets of course do exist, but even they are rare.

That said, we ought to be able to provide some quantification, some objective observations on atlatl function. However, we immediately face the question of what should be measured to determine atlatl efficiency. The damage inflicted by projectiles at different weights and velocities could be considered (Hrdlicka 2002, 2003). Some experimenters have measured dart velocity (Bergman et al. 1988; Hutchings and Bruchert 1997; Raymond 1986; Tolley and Barnes 1979), but accuracy and distance are the two most common measures of a successful throw. Both present problems of experimental design.

Distance is easy to measure, and so most experimenters have used distance of throws to measure the effect of variations in atlatl design. For instance, recent experiments have argued that variations in point size (Couch et al 1999), the addition of weights (Bird 1985; Peets 1960; Tolley and Barnes 1979), and the flex of the atlatl have little effect on the distance attainable in a sample of throws. However, other experimenters, using distance as a measure, have come to the contrary conclusions that the addition of weights to an atlatl increases (Mau 1963; Raymond 1986) or decreases (Hill 1948; Palter 1976) distance, and that flex and point weight are also important variables (Perkins 2000b).

Such inconclusive or contradictory results, while having the benefit of allowing observers to hold fast to their own biases, make it difficult to evaluate some aspects of atlatl design and use. Experimental design is to blame in many cases. First, there are many potential variables to manipulate in the equipment itself. It is possible to make atlatls and spears that are closely similar except for one variable such as position of the weight on the atlatl. However, hand-made gear is sometimes idiosyncratic, and one suspects a deal of noise is present in some experiments. Moreover, it is not safe to assume that the addition of a weight to a long, flexible atlatl has the same effect as the same weight on a short, rigid thrower, so generalizing statements are often difficult.

Furthermore, in my experience, even the best scholarly institutions are reluctant to allow experiments with projectile weapons in the gymnasium, and most atlatl experiments, especially distance throws, are necessarily performed outdoors, where inconstant conditions such as wind also introduce stochastic variation.

The worst problem of course is human variation. No one has yet designed a mechanical atlatl device that eliminates the human thrower. As modern sport atlatling demonstrates, each thrower has a slightly different motion, and each throw by the same individual is subject to small uncontrolled variations as well. This is because the motion of throwing is complex, involving the whole body, with several joints and limb segments acting as different lever systems in different parts of the throw. It is not possible to expect the consistency of a gun, a crossbow, or even a bow and arrow. Large samples of throws are necessary to compensate for this, but as exemplified earlier, most experiments have used relatively small samples, making their conclusions suspect in some cases, especially where the effects of relatively large human error might be expected to overwhelm relatively small variations in the equipment such as a few grams of point weight (eg Couch et al. 1999). In some experiments, several individuals used the same equipment. Although using multiple throwers efficiently increases the data set of throws, it also increases the human variation. However, if the goal is to understand a specific piece of equipment, we do need to see how different thrower physiques and styles affect performance.

The same problems apply to measuring accuracy, which is used by relatively few experimenters, although as Vanderhoek (1998) and others note, this is probably the variable most of interest to prehistoric hunters. Within a single experiment, a standardized target and a large sample of throws could make accuracy a useful measure, but there is even more human variation in how consistently you can hit a target than in how far you can throw when you try for a maximum distance. Accuracy is even more difficult to evaluate across different experiments. The atlatl is difficult to master, and modern atlatlists find it a challenging sport in part because even the most expert thrower is subject to occasional bouts of inaccuracy or unexpected wild throws. However, one of the basic premises of experiments with prehistoric technology is that the experimenter be competent enough in using a tool to give it a fair trial.

Sport and Science

The articles I cite include quite a few from recreational atlatlists. Along with traditional archery, flintknapping, and other primitive skills, the atlatl has experienced a surge of popular interest in recent years. Recreational atlatlists are as devoted and opinionated as enthusiasts in any sport and have developed a body of practical experience and a considerable literature. It is worth noting that this is not as new as many think, and a number of important early studies also came from atlatlists who had little other connection to archaeology. Following the "World Open Atlatl Contest" started in 1981 (Laird 1984), the World Atlatl Association was founded in 1988, and a number of state, regional, and European groups have also formed. The various newsletters of these organizations publicize some archaeologically relevant material. Because atlatls are fairly easy to make and use at an elementary level, but difficult to really master, they are ideal for teaching experimental archaeology, and for inspiring students and the public with respect and interest in pre-industrial technology (Whittaker and Mertz 2002).

As sporting use of atlatls has grown, there are even a number of people making standardized atlatls for sale. These are mostly not reproductions of specific prehistoric or ethnographic types, but those too can be purchased from skilled makers by experimenters who don't wish to make equipment themselves. More important, the sporting world of atlatlists not only involves some archaeologists like myself, but provides a relatively large body of experienced people, some actively experimenting and publishing, others capable of cooperating with experimenters. Much of the experimentation is unsystematic or undocumented (a problem not confined to amateurs), but even that produces subjective experience that is useful in judging archaeological atlatls. The sporting records that are developing are also more useful than most participants might think.

The International Standard Accuracy Contest (ISAC) was developed in 1996 by Lloyd Pine and is now used as part of most competitive atlatl events, with scores recorded and publicized by Pine and the WAA. The contest consists of 5 throws at 15 m and five at 20 m at a standardized bullseye target modeled after those used in archery. The rings are 108 cm, 80 cm, 56 cm, 40 cm, 24 cm, and 10 cm, scoring 6, 7, 8, 9, 10, and X (tie-breaking 10) points respectively, for a possible high score of 100 with 10 X (WAA 2005).

Although the ISAC was created by and for atlatl sports, so that there would be one standard of comparison among atlatlists all over the world, it can serve more serious research purposes as well. It is already apparent, for instance, that as sporting interest in atlatls grows, so does skill. More people are practicing, and over the last 8 years of ISAC records, the top scores have risen, and the number of people achieving higher scores has increased dramatically. European events using the same targets and distances for bows and atlatls show that proficiency with the atlatl is much harder to attain than with the bow and arrow (Cattelain 1997). In 2003 the highest score yet achieved in an ISAC competition was Mark Bracken's 98XXXXX. Scores in the 70s are considered competent but not exceptional. A detailed analysis of the 13,500 scores recorded between 1996 and 2003 (Whittaker and Kamp 2005a, 2005b) shows that although there will probably be some new records, the top atlatlists have reached a consistent peak. Furthermore, high scores and individual peaks are usually reached after only a couple of years of practice. ISAC competition includes people of all ages and skill levels, and the top teenagers and women are now achieving scores close to those of the men. What this all means to us is that although none of us has grown up using an atlatl daily, or been able to collect data on habitual subsistence hunters, we probably have a pretty good understanding of what ordinary people can consistently do with an atlatl.

One of the pleasures of the sport is in making and trying out new gear. Score sheets record whether competitors' equipment is "primitive" (no modern material allowed except glues and fake sinew) or "open." Atlatls and darts used in modern events include a few archaeologically supported replicas, but most are "inspired by" prehistoric gear, and made using modern tools and a wide range of natural materials. Some atlatls are fully modern innovations using space-age materials, and fiberglass and aluminum shafts are common as well as milled wood. In our ISAC data, scores with primitive equipment average slightly higher than scores for modern equipment, probably because some of the most adept and frequent competitors prefer "traditional" gear. (For practical tips on atlatl manufacture, see *The Atlatl*, bulletin of the World Atlatl Association http://www.worldatlatl.org/ and references in Whittaker 2004a).

Modern sporting use of atlatls is varied and eccentric, and was never intended to be scientific. However, the principles of atlatl use can be studied using even atlatls that would shock an ancient. Moreover, the ISAC serves as a standard against which some early experiments and ethnographic accounts can be gauged. Modern ISAC and other results allow me to say with confidence that if Browne (1940) concluded that "any close degree of accuracy is impossible with the atlatl," and Peets (1959) was unable to hit a man-sized target at 20-40 yards, they were doing something wrong. One could use the ISAC as a measure of accuracy in testing atlatl designs, or to calibrate experimenters.

Modern distance records with the atlatl are also useful. David Engvall holds the world record of 848' 6 5/8" (258.64m) for an atlatl throw using modern materials and designs (Engvall 1995; Tate 1995). Using primitive materials Wayne Brian's record is 581' 4" (177.19 m, Clubb 1994). The world record for a modern aerodynamically designed javelin throw is around 98m. These modern standards suggest that when Edge-Partington (1903) records Australians throwing light reed spears 300 yards with a woomera, and heavy wooden spears "accurately to a distance of 120 yards" by hand, we should wonder if these accounts are not exaggerated. Compilations of ethnographic records show that the normal hunting range for bow and arrow or for spear throwers was 10 to 30 m (Cundy 1989; Hutchings and Bruchert 1997). This accords well with the experience of modern sport atlatl use and competitive primitive archery.

Conclusions

Atlatl experiments have morals applicable to all experimental archaeology. The need for experiments grows out of archaeological problems of the day, but it is noteworthy that many old issues may be ignored for a while, but often they never really die. The two primary reasons for this are the difficulty of designing effective experiments, and the inconclusive or ambiguous nature of most archaeological experimentation. Even a simple technology may have many parts that can be treated as variables, and the element of human error, skill, knowledge, and experience in using any technology is often a major confusing factor. We cannot live as our prehistoric subjects did, nor think their thoughts, but to experiment realistically with their technology, we must become fairly proficient with it, and to compensate for the obscuring effects of random errors and variation in each act, we must create large samples of experimental trials. The recreational use of primitive technology helps in this, as more people become experienced users.

Even if we feel that we are skillfully recreating the use of a tool, there may be techniques or functions that our imagination and experiments have not encompassed. The fundamental weakness of replicative experiments of course is that they create only analogies to prehistoric tool use, a body of things we know work, and things we are pretty sure do not. Experiments do not quite substitute for actual observations of a tool in use in its living culture. The case of the Indian Knoll artifacts is a perfect illustration. Netting hook and sizer, or atlatl hook and weight? Experiments show that they work for either function, and it is only by examining other evidence, especially archaeological context, that we can build a convincing argument. However, the strength of replicative experiments is that they allow us to make much more realistic interpretations of the archaeological evidence, and inspire more imaginative ideas that can be tested against further experiment and the evidence of the artifacts.

Figure Captions

Figure 1. Four modern atlatls. Top to bottom: Simple “five-minute” model and Basketmaker inspired form by J. Whittaker; modern commercial Great Basin inspired form by Bob Perkins, BPS Engineering; modern commercial “Wyalusing” model by Bob Berg, Thunderbird Atlatls.

Figure 2. Ethnographic Australian atlatls, showing variety of forms.

Figure 3. Sequential photos showing throwing motion. Photos by Jeff Lindow.

Figure 4. Reconstructions of archaeological atlatls. Top to bottom: French Paleolithic by Pascal Chauvaux; Indian Knoll reconstruction, two interpretations of Cushing’s Key Marco finds, and a replica of coastal Peruvian atlatl 3743 in University of Pennsylvania University Museum, all by J. Whittaker.

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