HOW ATLATL DARTS BEHAVE: BEVELED POINTS AND THE RELEVANCE OF CONTROLLED EXPERIMENTS

Devin B. Pettigrew, John C. Whittaker, Justin Garnett, and Patrick Hashman

Beveled retouch on stone projectile points has often been considered as a device to spin and stabilize a projectile. A recent paper showed that a beveled point will spin a small shaft under tightly controlled laboratory conditions. However, this experiment has little relevance for real projectiles such as atlatl darts, which flex dramatically and spin unevenly in flight, quite independent of point form. The spinning is related to the flexibility of the dart, which is necessary for spearthrower function. A beveled point cannot spin a dart in the air, but is likely to cause some rotation when encountering a solid target like flesh. Beveled points are probably not related to spinning either darts or arrows in flight and present a good example of why we need to have both theoretical understanding and experimental observations of details of projectile behavior before interpreting artifacts. Spinning in a carcass could make beveled points more lethal, but the suggestion that beveling mostly results from sharpening and other modification of stone points remains the best explanation.

El retoque biselado en las puntas de piedra arrojadizas con frecuencia ha sido considerado como estrategia para hacer girar y estabilizar un proyectil. Un estudio recién mostró que una punta biselada hará girar una asta pequeña bajo condiciones extremadamente controladas en el laboratorio. Sin embargo, este experimento tiene poca relevancia en cuanto los proyectiles auténticas como los dardos del atlatl (estolica), que se flexionan dramáticamente y giran erráticamente en vuelo, no importa la forma de la punta. La rotación se relaciona con la flexibilidad del dardo, la cual es necesaria para la buena función del atlatl. Una punta biselada no puede hacer girar un dardo en el aire, pero probablemente va a causar algo de rotación cuando encuentra un blanco sólido como la carne. Las puntas biseladas probablemente no se relacionan con la rotación de dardos ni flechas en vuelo, y presentan un buen ejemplo de la necesidad de tener ambos el conocimiento teórico y observaciones experimentales de los detalles del funcionamiento de los proyectiles antes de interpretar los artefactos. La rotación en una carcasa podría hacer más letales las puntas biseladas, pero la sugerencia que el biselado resulta principalmente del afilamiento y otras modificaciones de las puntas de piedra permanece la mejor explicación.

Before the bow and arrow, in most parts of the world there was the spearthrower, or atlatl, a peculiar but highly effective weapon system. There are many different forms, but all are similar: a shaft with a handle on one end and a hook or socket to engage a light spear on the other. Atlatls appear in the Upper Paleolithic of the Old World and Paleoindian times in the New World. They were common over much of the world until replaced in most areas by the bow and arrow, but atlatls continued to be used until historic times and are still used in the present in Mexico, the Arctic, Australia, and elsewhere.

Despite more than 10,000 years of hunting success, a century of archaeological experimentation, and current recreational use, a lot of basic information concerning their use is still in question. Details of how spearthrowers work, how powerful they are, and how different forms of projectiles behave remain to be explored. For instance, some believe that atlatls flex like a bow and spring the dart away, despite abundant evidence that this is not so (Whittaker 2015; Whittaker and Maginniss 2006). The atlatl is a lever, or rather performs as one of a system of levers, which include the various joints of the body and

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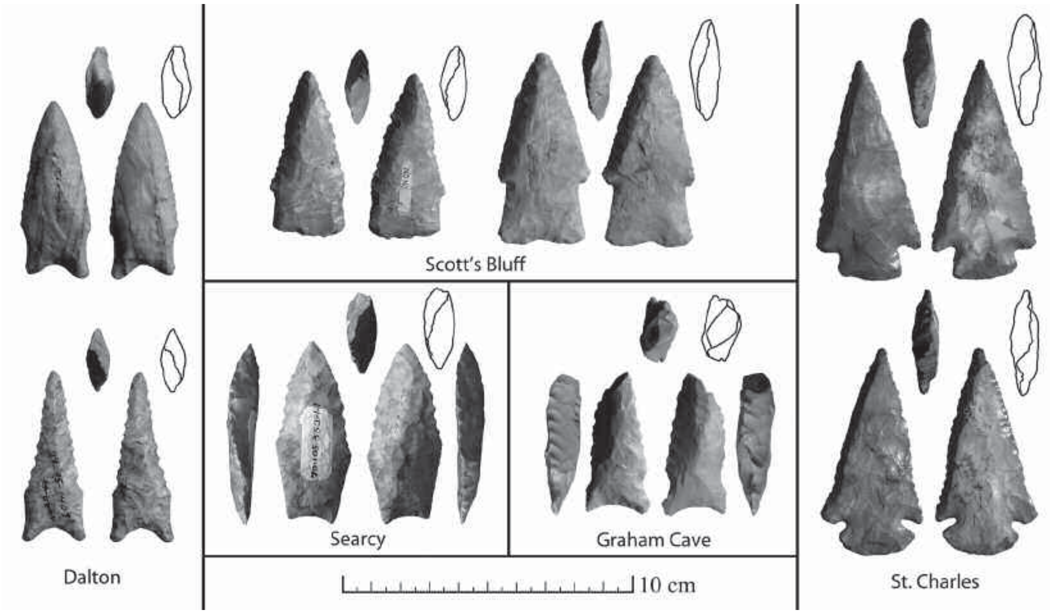

Figure 1. Examples of Archaic beveled points. Dalton points, courtesy of University of Arkansas Museum Collections. All others, courtesy of Arkansas Archeological Survey collections.

arm. A normal overhand throw, such as is used with a rock, a ball, or an atlatl, begins with the large, slow muscles of the legs and torso, and ends with a snap of the wrist, which imparts much of the final velocity to the projectile (Cundy 1989; Whittaker 2010). As the atlatl flips away the dart just as the fingers do a ball, the lever arm at the hand and wrist is greatly extended, and a light spear can be thrown much farther and faster than by the hand alone. The limitation of this system is that you cannot increase the length of the atlatl or the weight of the dart too much before it becomes inefficient, requiring more force input from the hand than most humans can manage.

We have a lot of advantages over our ancestors when it comes to figuring out how a tool works. Modern technology allows observations and measurements that were previously impossible, and new ways of visualizing processes. Our understanding is bolstered by applying well-supported mechanical and physical principles. We can design experiments that isolate individual variables and use mathematical models to sort out their relationships. The problem with all controlled experiments and theoretical models is that they may be too far from the practical reality of a prehistoric technology; they necessarily examine too few of a suite of interacting variables. A little bit of real experience with any technology goes a long way.

It has become fashionable to talk about design principles and engineering of early tools, a perfectly good idea in many cases (Hughes 1998). However, there are two problems with some of the discussions of design of ancient tools. Many are based on theory, "common sense," and generalizing references to experiments performed under many variable and specific conditions that are not always well documented, rather than coming from the theorists' practical experiences with a tool. And some experiments, however well-designed, are too far removed from reality to be easily applied. This comes partly from one of the strengths of controlled experimentation: the ability to isolate individual variables by using artificial conditions.

Beveled Projectile Points

Beveled projectile points present a problem that has interested archaeologists since the nineteenth century. Beveled points (Figure 1) are most common in the Early Archaic of the Midwest, but occur elsewhere as well. There are two main competing theories explaining why prehistoric knappers beveled large points rather than making a symmetrically sharpened bifacial edge. Most common is the idea that beveling results from ef-

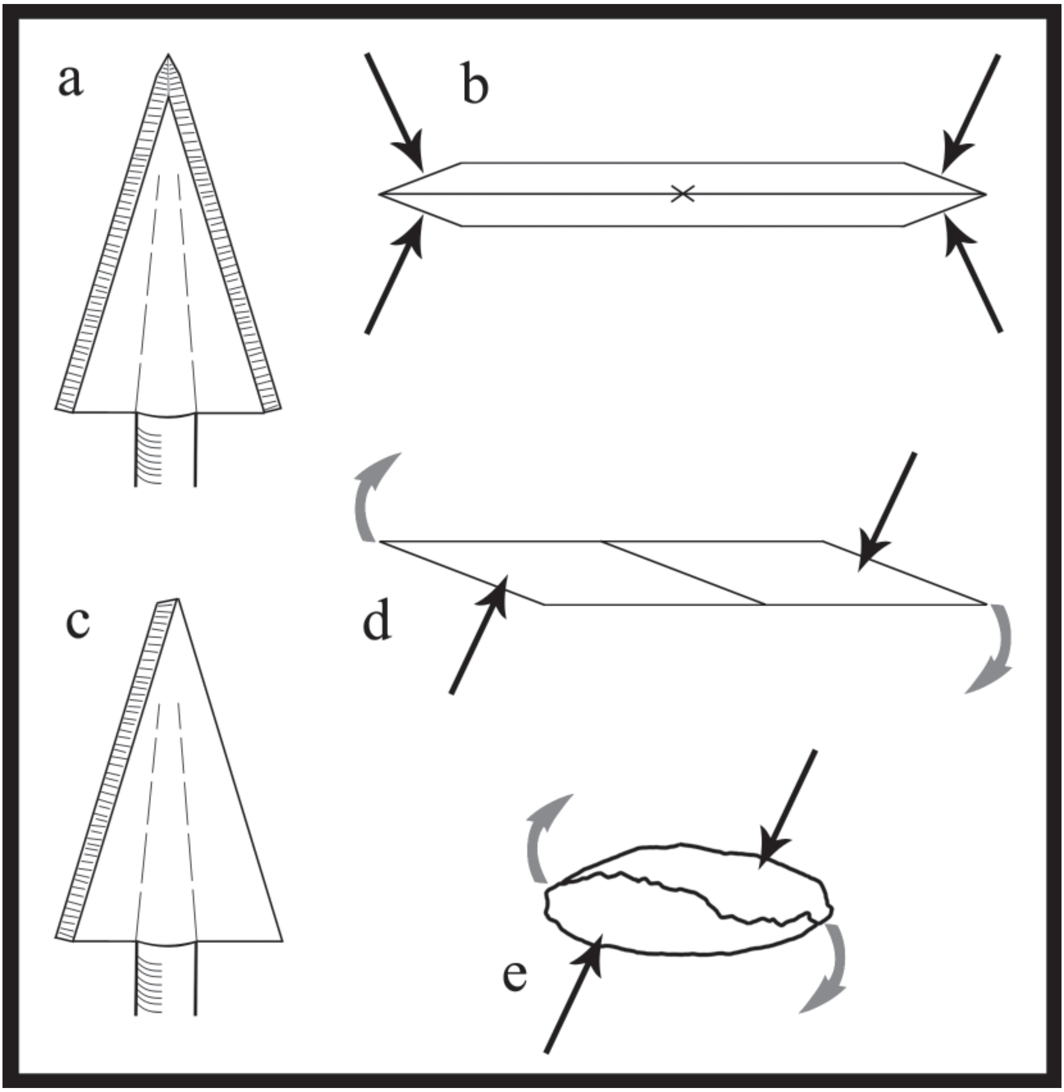

Figure 2. A diagram showing the effects of beveling (straight arrows indicate resistance against bevels, curved arrows indicate direction of rotation): (a) side and (b) head-on views of a bifacially sharpened "unbeveled" metal point; (c) side and (d) head-on views of a unifacially sharpened "beveled" metal point; (e) head-on outline of a unifacially sharpened "beveled" stone point (Figure 5b).

ficient resharpening of a tool that was probably used at least part-time as a knife. Beveling, working alternate faces of opposed edges, sharpens the edge while removing less material than bifacial resharpening (Morse 1997; Sollberger 1971). Also, it may be more convenient to resharpen tools that are in a haft by beveling. The apparent use-life progression of tool forms with similar bases and modified blades is often considered evidence of this (Bradley 1997; Sellers 1886). The large size of some beveled points also makes projectile use unlikely and supports a knife-like function for at least some examples, although some smaller specimens show the impact damage considered diagnostic of projectile use.

A second school of thought has proposed that bevels were put on points to stabilize the flight of the projectile by making it spin, analogous to the effect of spiraled fletching on modern arrows, or rifling on a bullet (Figure 2). This idea has been around a long time, since the nineteenth century (Hough 1891; Peale 1861). As one early commentator (Tait 1874:245) put it, “if the weapon was propelled with any great rapidity, its revolution would be a matter of necessity and would result in a greater steadiness in its line of trajectory.” He means that, because the point is shaped like a propeller, it is inevitable that it would spin.

The reason this trivial attribute of a small class of artifacts is of interest is that it affects our understanding of the efficiency of a common weapon and our view of technological change and invention through time. For instance, it has been argued that we see the invention of fletching for atlatl darts at the point in the Archaic around 6500 B.C. when most points stop being beveled (O’Brien and Wood 1998:96).

Testing beveled points was one of the early projects of experimental archaeology and, typically, produced ambiguous results. Thomas Wilson (1898, 1899) tried a simple experiment: he hafted beveled points on unfletched shafts and dropped them from a tower. He found that they did in fact spin and got similar results with a primitive wind tunnel and in water. On the other hand, Smith (1953) claimed to have shot unfletched arrows with beveled points and observed that they did not spin. Both of these experiments, and others like them, have problems with methods and with the ability of the observer to actually see what is going on.

Most recently, Carl Lipo and associates have produced papers (Harper et al. 2007), including one in *American Antiquity* (Lipo et al. 2012) arguing that beveling on Archaic points improved accuracy by spinning the projectile and thus was subject to selective forces. They point out that aerodynamic theory supports bevels as producing spin. Spinning a projectile converts the curved path of an unevenly curved shaft to a helical path because bias in the shaft is rotated in all directions. Rotation rate is a function of velocity, bevel surface area, and angle of the bevel. A computer model using fluid dynamics simulated the effect of air moving across different biface shapes to see whether a beveled point would cause spinning in a real-world situation. Their model showed that spinning forces should be created at wind speeds consistent with prehistoric projectile velocities (5–60 m/sec; Hughes 1998). These velocities, equivalent to 16–198 fps, or 11–132 mph, in fact range well above dart speeds (Pettigrew 2015; Whittaker 2013; Whittaker and Kamp 2007). Wind tunnel experiments at 30 m/sec (which at 67 mph is a more realistic dart velocity) on bifaces mounted on a freely rotating axis show that they do indeed rotate. Rotation should improve accuracy and reduce drag of any attached shaft, so it should be selected for once it has been invented. Since not all points are beveled, there must be certain conditions in which beveling is advantageous. The advantage would be seen mostly on larger points, which would be hafted on larger shafts, whose rate of rotation will increase more slowly. Light objects at the same starting velocity do not travel as far, so any rotation would have less effect, which may explain why arrow points are not beveled. The optimum payoff for rotation would be for projectiles weighing about 100 grams. According to Lipo et al. (2012), beveling in North America originates with Dalton, from which developed two lineages of large point forms that were often beveled: notched forms such as Thebes points, and stemmed forms like Hardin Barbed (Justice 1987). Earlier Clovis points were mostly multipurpose tools for stabbing and cutting and thus were not beveled. Dalton forms were more functionally specific projectile points. After the early Archaic, beveling was abruptly abandoned, signaling less need for accuracy, or different technological solutions, perhaps fletching.

We see no reason to doubt that a large beveled Archaic point can spin a small straight shaft in a wind tunnel. *But this experiment is completely irrelevant to the behavior of real projectiles, and the archaeological conclusions derived from it must therefore be discarded.*

An atlatl dart in flight does not behave like a small straight shaft in a wind tunnel.

The motion of a real atlatl dart is far more complex than the Lipo et al. (2012) model assumes. An atlatl dart must be flexible, because the motion of the atlatl that propels it is rotational (Figure 3; Supplemental Video 1). As the hook of the atlatl rises with the nock end or tail of the dart, the dart must flex to keep the point aimed toward the target. In general, the dart first flexes upward, then, as the atlatl continues to rotate, it may be pulled down and, somewhere along the way, the dart flies off the atlatl and continues to oscillate for a while before stabilizing. The flexi-

bility of a dart shaft is actually quite shocking when seen in slow motion. In fact, it is amazing to us that atlatlists can consistently hit a target with what looks in slow motion like a flying noodle. Even to the naked eye, the oscillation of a good dart in flight is dramatic and surprising (Supplemental Videos 2 and 3).

Because darts have a "spine," or a weak side that biases them toward flexing in one direction, the shaft can quickly spin as it oscillates to align its spine with the new direction of flex. This can result in uneven spinning that can even change direction in mid-flight. Sometimes the dart may fly down range flexing toward one side and rotating through the air in a kind of "crank-shaft" effect. The oscillation and uneven balance of a dart usually produces some combination of these effects, and it is often difficult to tell exactly what is happening, even in high-speed video. However, neither a beveled point nor fletching is enough to overcome these effects at normal target ranges of 10 to 30 m. On very long throws, after the oscillation of the dart ceases, fletching may have an effect.

Most darts can be seen to spin, but they do not spin because of their points. We can now explore the effect of point beveling and other aspects of atlatl projectile behavior through experiments more relevant to prehistoric dart use, using the observational capabilities of modern technology. Can a beveled stone point on the end of a long, heavy, flexing dart actually make it spin? An experienced atlatlist should doubt it, but the proper thing to do is to test it. Even with a slow motion camera, it is difficult to accurately observe details of small objects in rapid motion. A series of experimental observations begun by Whittaker (2012), and improved by the authors, systematically varied the points and fletching of darts and filmed them with a Casio EX-F1 high speed camera at 600 and 300 fps.

Several different atlatls were used in the experiments, but they were consistent in each set of trials, and equipment that the throwers used often. Darts were fletched with three parallel feathers of different colors and marked with stripes along the shaft to make any rotation visible (Figure 4). To keep the darts consistent while varying the point,

Figure 3. A typical throwing (Whittaker) sequence showing dart tail flexing up, down, and up, due to the rotational motion of the atlatl in throwing.

two sets of points were made by Whittaker (Figure 5e) and mounted on plastic tube foreshafts so they could be interchangeably installed on the darts. Four similar dart points were tested, two of stone, two of wood. The form was similar to large versions of Hardin Barbed points, an Early Archaic Midwestern form that is often found beveled (Chapman 1975:249; Justice 1987:51–53; O'Brien and Wood 1998:125–128). Each set was similar in size and weight, but one point in each set was strongly beveled, the other not.

In the sequence of frame captures from one typical throw, the dart's flex and oscillation is readily visible (Supplemental Figure 1 and Supplemental Video 3). Darts in flight can often be seen to spin, but the spinning is in bursts and not even. In fact, as Video 3 shows, a dart may even reverse the direction of its spin. As the dart in Video 3 has parallel fletching and a conical tip, it evidently rotates even without spiral fletching or a beveled point, reinforcing how irrelevant these are to dart motion. The results were no different with points added, whether they were beveled or not (Supplemental Videos 2, 3, and 4). Strongly beveled points should spin the dart counterclockwise if they were effective; they did not.

In the video record of the experiments, as well as less formal recorded examples (Supplemental Video 4), it is clear that different darts—with a conical point or no point, with an unbeveled point, and with a beveled point—all behave unpredictably: some spin consistently in one direction, some in the other, and some reverse their direction of spin in flight. Readers resistant to this idea will perhaps want to claim that our throwers are simply incompetent with the atlatl, or that our equipment is faulty, but neither is the case. Each of the authors has several years of experience both making and using atlatl equipment of a wide range of forms, and we all participate regularly in atlatl competition. The video clips (and others which can be found on YouTube and elsewhere) include throws by various other skilled atlatlists. The behavior of the darts in our controlled experiments are the same observed thousands of times over many years watching ourselves and dozens of other throwers with all sorts of equipment.

Figure 4. Example of an experimental dart marked with stripes and colored fletching; Hashman preparing to throw during the hog carcass experiment.

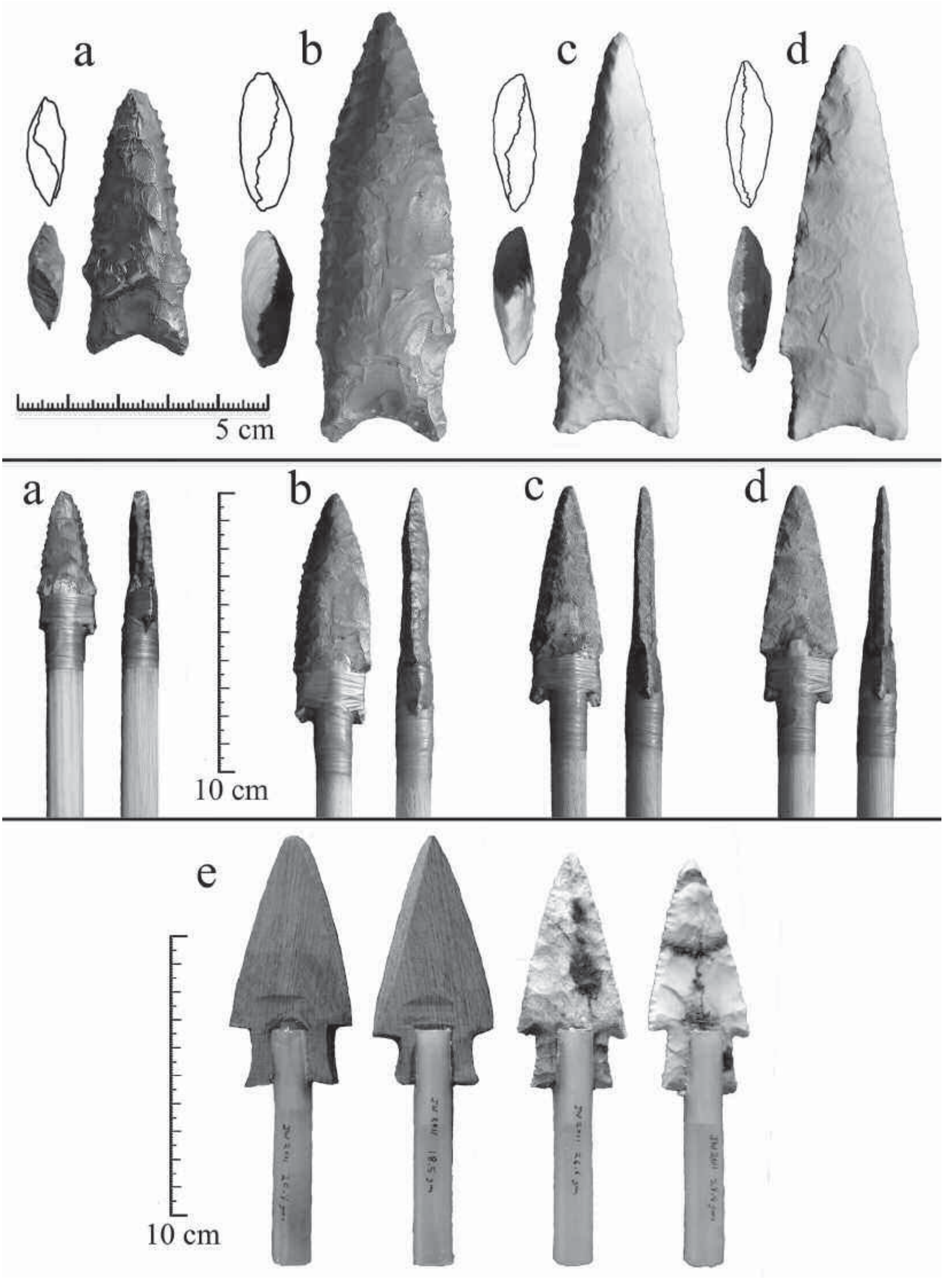

Figure 5. Examples of test points: (a–c) beveled; (d) non-beveled stone points used in penetration tests; and (e) beveled stone and exaggerated wood points used in flight tests. Points made by John Whittaker (a, c, d, e) and Larry Kinsela (b).

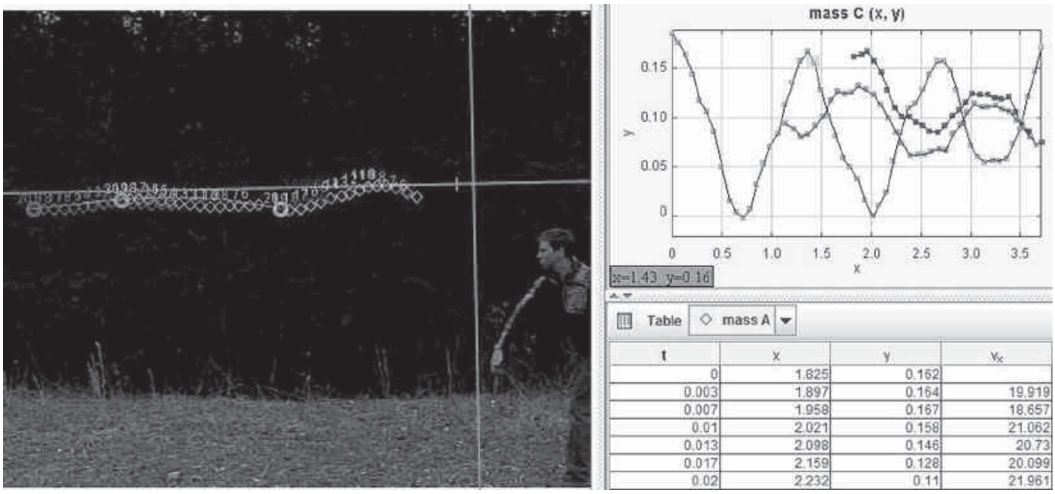

Figure 6. Measuring displacement of the tip, mid, and tail of a dart during oscillation using the Tracker video analysis program (http://www.cabrillo.edu/~dbrown/tracker/) and a Casio EX-F1 high-speed camera at 300 fps. The dart was marked with visible points at the tail, center of balance, and tip. Points on the graph show the oscillation for the dart's entire flight across the screen. Points beginning on left and running across the full width of the graph represent the tail with the highest oscillation, then the center of balance and tip respectively. X and Y units are in meters.

It appears that any spinning of atlatl darts in flight is complex, a function of the oscillation of the dart, not of the feathers or the point. However, there is variation between throws, and even in slow motion it is not always clear what exactly is happening. This also suggests that it would be even less clear to the naked eye of a preindustrial atlatlist, who would probably lack any theory about why a beveled point should rotate a shaft. This suggests at least that beveling was not a conscious attempt to stabilize a projectile, and we have shown that in fact it did not have that effect.

What kind of abilities do we humans have that allow us to predict the flight path, or at least the impact point, of such a strange projectile? Experience teaches one to coordinate the body and cast the dart with the proper trajectory downrange, while a host of characteristics ensure that it has proper flight (see Cundy 1989 for a detailed discussion). It seems likely that anything that makes the dart fly more predictably and accurately would be advantageous, and that is the adaptationist position argued by Lipo et al. (2012). But does a beveled point help a dart fly accurately? Apparently not.

On the issue of accuracy, it should also be briefly noted that, because the dart is flexing and spinning, the point does not move in a straight line. We can at least measure its vertical motion in two dimensions (Figure 6) and see that for this example dart and throw, the dart oscillated about 6 cm at the tip, while the tail oscillated more than 15 cm. Among the tail, center of balance, and tip, the tip is the most stable. This stability is probably due to the taper of a natural shaft. Yet, there is an inherent limit to the accuracy of the dart due to the oscillating tip.

Target-Impact Rotation Experiments

The experiments discussed above convinced us that point beveling will not induce an atlatl dart to spin in flight; there is simply too much going on with the dart for air resistance against the bevels to have any effect. However, what about when the point encounters the body of a target? Modern archers have recently been using single-bevel points for hunting, claiming that they create a myriad of effects leading to greater lethality. The most active proponent of beveled broadheads has been big game hunter Dr. Ed Ashby (Ashby 2005, 2007, 2010). He claims that single-bevel broadheads penetrate better and do much more damage, cutting a curved or spiral wound through flesh, organs, and blood vessels, and torqueing and fracturing bones.

These effects are produced because pressure is exerted against the bevels, which causes rotation

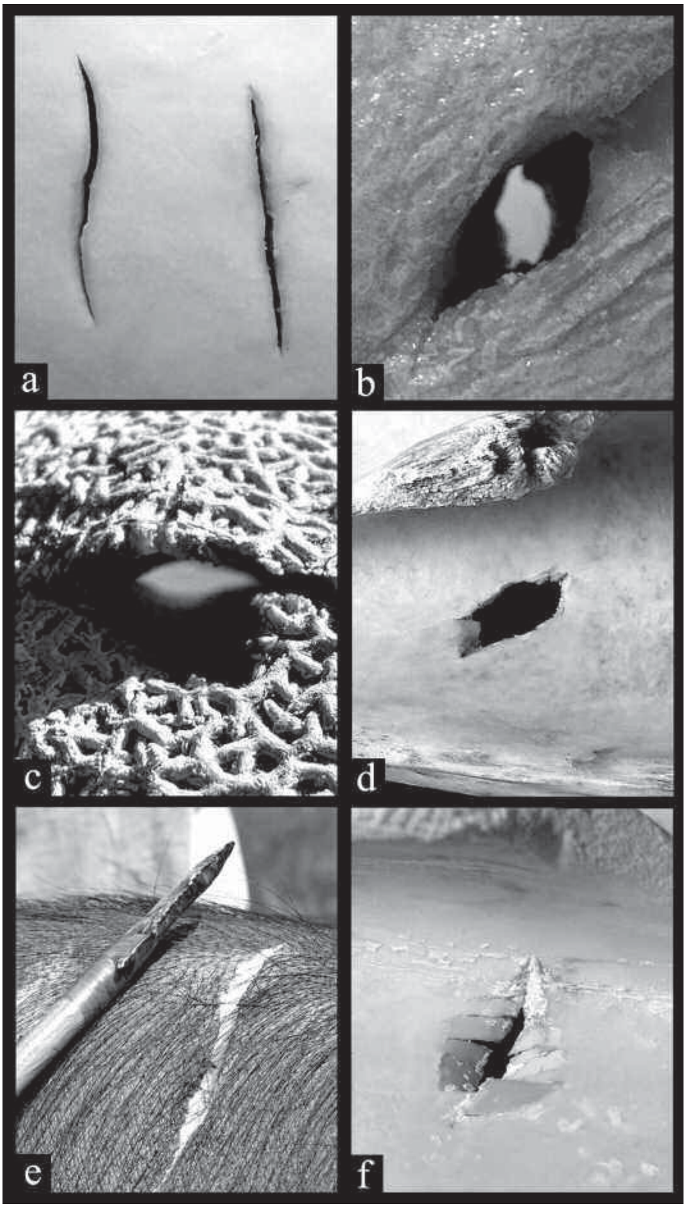

Figure 7. Examples of bevel effects in solid mediums: (a) beveled (left) and non-beveled (right) metal points (e.g., Figure 5a–d) manually pressed into a honey dew melon; (b) peering through a cantaloupe shot with a beveled point (Figure 5b) (Supplemental Video 5); (c) a cantaloupe shot with a non-beveled point (Figure 5d) (Supplemental Video 5); (d) a fresh pig scapula shot with a beveled point (Figure 5c) (Supplemental Video 6); (e) an S-shaped slice in hog skin made by a glancing blow from a beveled point (Figure 5b); (f) a scapula from a fresh hog carcass shot with a beveled point (Figure 5c).

and a spiraling cut. Whether the effects of beveled points are as dramatic as Ashby claims is unclear and not really the point here, but it seemed possible that a medium more resistant than air might be able to spin a dart armed with a beveled point. To test whether Archaic beveled dart points would spin a projectile in target flesh, and might have similar effects as modern broadheads, a number of experiments were undertaken (Pettigrew 2015) and recorded with the high-speed camera.

Cantaloupe and honeydew melons worked to demonstrate that in a solid target of the right composition (Ashby 2007:6), beveled points will cause a dart to spin (Figure 7a, b), while bifacially sharpened points will not (Figure 7a, c) and indeed will stop spinning if the dart is spinning prior to impact. With both metal and stone beveled points mounted on a river cane dart (*Arundinaria gigantea*), the dart rotated approximately 1/8 turn through a cantaloupe (Supplemental Video 5). Melons worked to demonstrate rotation, but are not necessarily a good proxy for animal prey. To substantiate these results we needed to test beveled points on real flesh and bone. Videos can be found on the internet (Schlief 2012) of archers shooting single-bevel broadheads into fresh bone to demonstrate the splitting effect. Several tests with atlatl darts were therefore made on bone. Dried and fresh cow ribs showed some potential for metal beveled points to cause splitting, but even large darts with plenty of momentum could not penetrate these heavy bones (Supplemental Video 6). A stone point thrown into a fresh pig scapula simply punched a hole through without splitting it (Figure 7d, Supplemental Video 6).

The authors also tested bevel rotation on an animal carcass. A 220-lb Hampshire hog was killed humanely and mounted on a trestle. An arsenal of atlatl darts mounted with consistent foreshafts and a variety of points were thrown into the carcass as part of Pettigrew's Master's thesis research (Pettigrew 2015). Each shot was recorded using two Casio high-speed cameras, an EX-F1 and an EX-ZR1000, for flight and velocity analysis. Of the 29 foreshafts, 11 carried beveled stone points knapped by Whittaker or Larry Kinsella. Both of these knappers have many years of experience and a good understanding of the process of making beveled points. The beveled points were hafted on 1/2-inch oak dowels using modern adhesives and artificial sinew (Figure 5a–d) for consistency and reliability in multiple throws. As observed in the melon tests, single-bevel points penetrating around 20 cm into the carcass rotated approximately 1/4 turn, while double-bevel (bifacially sharpened) points did not rotate. This rotation was easily felt by all four experimenters when retracting the darts from the carcass.

Resolution of the carcass experiment videos (300 fps) is not perfect, but dart rotation is visible on some of the videos (Supplemental Video 7). One heavy ash dart skipped off the top of the carcass and the beveled point made an S-shaped slice through the skin and fat (Figure 7e). The majority of shots were taken at 12 m, a good distance for atlatl shots and one that would be typical of hunting ranges (Cattelain 1997); however, the final shots were taken from closer in an attempt to hit the scapula. The final throw was made by Garnett using the same beveled stone point and cane dart used for previous melon and scapula tests. As before, the point punched a hole through the scapula (Figure 7f), but did not split it, and continued on to lodge in the spine. Due to its shallow penetration (10.2 cm), rotation could not be seen in the video on this shot. One thing is certain: whether beveled or not, stone points on atlatl darts are very effective. We consistently obtained penetration of 15–20 cm. Points that directly impacted solid bone were usually stopped, but points often notched ribs and continued onward, in some cases damaging the inner surface of ribs on the opposite side of the hog. Further documentation of the experiment, dart penetration, and effects on bone and the stone points is contained in Pettigrew's thesis (2015).

Discussion

Our observations demonstrate that beveled points do not spin a projectile in flight, but may rotate in target flesh. We have not experimented enough with carcasses to see whether they have the effects claimed for single-bevel steel points by Ashby. It is important to remember that not all beveled points are the same and that there are a number of possible reasons why Archaic points may have been beveled, as well as different forms of beveling. Resharpening remains the best explanation for most beveling. Both points and knives may be efficiently resharpened by beveling, whether on or off a shaft. Later small arrow points are only rarely beveled, not because any spin would be less effective on such projectiles, as claimed by Lipo et al. (2010, 2012), but because they usually have short use lives with less chance for resharpening, and they usually do not see secondary use as knives that might need resharpening.

Sharpening a point by beveling saves material, and, in so doing, a thick, robust point can still hold an effective cutting edge. For example, one of the experimental points, a stubby, reworked Dalton with a chisel tip (Figure 5a), was thrown a total of 10 times with only one miss. Five of these were hard throws from close range in an attempt to hit the scapula. Even during the throws at 12 m, this small point on a light cane dart penetrated deeply into the carcass, sometimes almost pushing out the back. At least one throw struck bone (probably a rib, which could be felt and heard while retracting the point). However, the point did not break or show any visible signs of damage throughout the experiment. This suggests that worked-down points, common in Early Archaic contexts, were more effective than one might imagine.

We agree with Lipo et al. (2012) and others (Mesoudi and O'Brien 2008) that it is useful to think about selective forces applied to technologies. Beveled points were used for a long time, and Archaic hunters must have seen advantages in beveling points in some contexts. However, selective advantages of beveled points did not include any ability to spin and stabilize a dart in flight, and it is unlikely that ancient hunters, without theories of dynamics, believed that they did.

However, beveled stone points can turn in a carcass and perhaps create more damaging wounds. Ancient hunters who relied on hunting as a way of life, and were exceptionally skilled at it, could have noticed some benefits of point beveling and sought out beveled points. However, beveling on ancient stone dart points could also have been purely a result of more efficient resharpening and resulting reworked point design. We withhold judgment until more evidence can be gathered.

There are also some general morals about experiments in archaeology that should be drawn from considering beveled points. Controlled, artificial experiments, such as those by Lipo and his team, in which we can isolate individual variables like beveling, are necessary and useful. However, because they are often artificial, they are sometimes too far removed from real use of a prehistoric artifact. The best experiments with prehistoric weapon systems are often those that involve developing high skill levels, using equipment closely modeled on ethnographic and archaeological examples in situations resembling traditional usage. Such experiments are most likely to produce end results applicable to past usages. On the other hand, such "naturalistic" experiments often include many uncontrolled variables, inconsistency from one trial to another, and problems of objective observation, even with modern instruments. They also require a heavy investment of time in developing the necessary skills to make and use the prehistoric technology (and sometimes the modern observational equipment as well). Nevertheless, naturalistic experiments not only produce realistic results, but also are necessary if we are to discern the variables that may need testing under more controlled conditions. Experimental archaeology usually proceeds best when different kinds of experiments work together to inform each other, and some practical experience with a technology is always necessary to understand the pertinent variables and make reliable interpretations.

Supplemental Materials. Supplemental materials are linked to the online version of this paper, which is accessible via the SAA member login at www.saa.org/members-login:

Supplemental Figure 1. Stills from a 120 fps video showing the oscillation of a dart in flight.
Supplemental Text. Methods and Data.
Supplemental Table 1. Summary of flight tests.
Supplemental Table 2. Measurements of experimental beveled points used in flight tests.
Supplemental Video 1. Several atlatlists filmed in slow-motion.
Supplemental Video 2. Observing the effects of dart behavior in flight.
Supplemental Video 3. Alternate spinning of a dart shaft in flight.
Supplemental Video 4. Effects of point beveling on dart flight.
Supplemental Video 5. Testing beveled dart points in cantaloupes.
Supplemental Video 6. Testing beveled dart points on bone.
Supplemental Video 7. Testing beveled dart points on a pig carcass.

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