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ABSTRACT: The paper proposes a new biology of movement, one based upon movement itself as an empirical phenomenon. In consequence, it proposes a new area of biological study, comparative movement. The importance of this area to evolutionary understandings of the human past is shown in an abbreviated analysis of a taxonomic character identified through the new approach. Through such kinetic analyses, the mapping of kinetic domains across the animal kingdom emerges as a central possibility.

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Western-acculturated eyes tend to see objects moving rather than moving objects. In consequence, movement is described not in its own terms but in terms of where it comes from--anatomy--or where it is going--behavior. Along with anatomies and behaviors, however, movement too has evolved. To understand this evolution movement itself must be the center of attention; anatomy and behavior become peripheral but by no means irrelevant.

To see moving objects rather than objects moving is to see energy patterns rather than matter. Which of the two is seen is a matter of both focal-peripheral attention and conceptual orientation. For example, the traditional manner in which movement is conceived by biologists is as the sum of spatio-temporal displacements of anatomical parts or as the vectoral sum of other spatio-temporal coordinates. Such a conception idealizes movement by taking it out of its empirical context and placing it in a logico-mathematical one. Seen in its empirical context, movement is a kinetic process: attention is focally directed toward what is dynamically happening rather than toward what is materially present.

The purpose of this paper is not to question the traditional treatment of movement but rather to propose an additionally significant and valid one: a conception and analysis of movement based upon movement itself as an empirical phenomenon. On the basis of this new approach, it is possible to construct a taxonomy of movement in which kinetic characters come from an analysis of the phenomenon of movement rather than from anatomical or behavioral correlates. In effect, the new conception and analysis make possible a new area in biology, comparative movement.

To approach movement as kinetic process affords a new and challenging vantage point upon the animate world and the way in which that world evolved. New understandings emerge which enlarge and enrich the evolutionary picture. The significance of kinetic domains to paleoanthropological reconstructions is a case in point. What the latter require is a descriptive biology. What is reconstructed are not actual but prototypical behaviors on the basis of fossil evidence. The problem is that fossils themselves are not the stuff of which behavioral conjectures are made; it is movement, or more specifically, it is the assumed kinetic domain of the species in question which grounds behavioral speculations and links fossil evidence to behavioral reconstructions. But it is not only that movement must be acknowledged and spelled out rather than assumed, it is also that movement cannot reasonably be passed over on the grounds of anatomy, i.e., fossil remains, since the mere possession of an anatomical part does not guarantee any particular behavior. Thus insofar as the major quest of the paleoanthropologist is to reconstruct the human past, and in perhaps greater detail than any other reconstructed species, differences in kinetic domains--as evidenced by quadrupedal and bipedal lifestyles, for example, or, in a broader context, by aquatic and terrestrial lifestyles--are clearly pivotal evolutionary factors deserving investigation.

What would be desirable actually is a two-pronged approach: to observe and to analyze movement itself and ask what its characters say in terms of human evolution and to ask of any stock hominoid character what it says in terms of movement. Space

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allows a brief illustration of only one of these approaches. It will be assumed that the human evolutionary character, upright posture, was interrogated in terms of movement and that ballistic movement was uncovered as a kinetic possibility engendered by that posture.

Ballistic movement is movement which is, from the moment of release, self-propelling.[1] An initial thrust of energy sends the movement on its way, the amount of force and the velocity first increasing then decreasing as the initial energy and its gathering momentum are spent. Direction, velocity and distance are engendered by the initial thrust. At a strictly empirical level, the potential for ballistic movement lies in the kinetic difference between freely moving parts and freely hanging parts. Hence what appears unique about a human body is not the possibility of ballistic movement per se but the possibility of a broad and complex range of ballistic movement. Without this form of energy release, body movement can be seen to be basically either sustained or abrupt, energy being released either in an unbroken, ongoing fashion or in a staccato, percussive manner, respectively. The energy pattern in ballistic movement is in fact quite distinctive in the sense of having inherent subtleties. As noted above, intensity (amount of force) and velocity are not constant; the nature of the movement itself is such that both change gradually throughout the movement as a whole. In contrast, velocity and intensity do not necessarily change in sustained or abrupt movement. It should be noted that what is being referred to here and in all given examples is "pure" sustained, abrupt and ballistic movements. In actuality, a human body is not at all constrained to moving in "pure" patterns. On the contrary, permutations are not only possible but common. Thus, ballistic movement may be and often is interwoven with sustained and/or abrupt movement as will be presently shown.

On the basis of this initial description, it is possible to specify ways in which ballistic movement enters into the kinetic domain of humans and contributes to their extraordinary diversity of movement. To begin with, quite apart from permutations, the number of possible variations increases geometrically with the possibility of ballistic movement. It is of course true that any third kind of energy release would provide an increase. The introduction of ballistic movement, however, may be shown to be of preeminent significance in respect to the gamut and complexity of movement engendered by those increased possibilities.

Precisely with the inherent play of energy peculiar to ballistic movement, all kinds of preeminently human movements emerge: throwing, kicking, hurling, bouncing, swinging, skipping, flailing, punching, and so on. Whether purely ballistic or an admixture of projectional qualities, the movement is characteristically human and open to a seemingly limitless range of possible variations. If this kind of movement is examined along with a closer analysis of sustained and abrupt movement, notable distinctions become apparent, and particularly so if all of these movements are imagined in the context of early hominid life. Imagine a hominid body ducking, for instance, or grabbing, or hitting. Sudden power bursts are the very quiddity of abrupt movement. An instantaneous release of force is apparent. Were one to generalize on the basis of this fact, one might say that abrupt movement is basically power- and/or speed-oriented. Sustained movements, on the other hand, are not instantaneous releases of energy but ongoing, steady progressions. Imagine a hominid body stretching, for instance, or drawing something toward itself, or reaching, or taking aim. The temporal dimension of movement is expanded in relation to abrupt movement. Generalizing on the basis of this fact, one might say that sustained movement is basically precision- and/or attention-oriented. The notable and significant difference between a power and precision orientation might be specifically illustrated in the two common behaviors of pushing and pulling. If sustained, the effort is more likely toward moving something along a certain path, either propelling it (pushing) or dragging it (pulling) toward a certain place or creature. In both cases, the emphasis is on accuracy in respect to the object and the chosen path. If pushing or pulling is abrupt, effort is more likely not toward moving an object per se, but

toward forcing it, and suddenly, that is, toward deflecting it--perhaps onto a different path--or making it move more quickly. In other words, a directional and velocity shift is enforced; the emphasis is on controlling the object, literally overpowering it. According to the manner in which energy is released, then, an object might be tugged or dragged, shoved or pressed, power being at one time visibly predominant in the movement, precision being at another time visibly predominant.

The capacity to move with either a precision/attention or power/speed orientation is significant not only to hominid life but to a broad spectrum of creatures in the animate world. Indeed, simple observation would seem to show that it is basic to all hunting behavior, whether human or nonhuman and whether with or without tools. Predators have the capacity to approach their quarry in a stealthy, uniform flow of movement or to zap their quarry in a sudden deathly thrust of tongue or clamping of jaws. Prey and predator alike have the capacity to move in great bursts of power by which they change the direction of a charge or ward off an impending one. Pursuit strategies in which one species of animal chases after another involve power bursts which take on a ballistic character as well; the animal rides its initial propulsive thrust in moments of air-borne suspension. It is not a matter here of locomotion--of running, for instance, in these latter two examples--but of observable kinetic processes, that is, changes in the form of energy release without which there would be no hunt at all.

To look at hunting, in fact, from the viewpoint of kinetic processes changes the usual conceptual orientation toward the phenomenon. What one discovers from the new vantage point are insights into the different ways in which animals literally make their different ways in the world: movement possibilities bespeak a certain overall kinetic character which defines the unique dynamic patterns of energy belonging to them. In effect, identifiable kinetic domains emerge, domains which are not simply described in terms of general behavioral or qualitative factors--e.g., this animal is sluggish, this one is agile--but in terms of observable and specifiable energy patterns. In short, kinetic characters add up to a certain way of doing things, to certain capacities, and to certain potentialities. In this sense, a hunt is not only the means by which certain animals obtain food, for instance, or a phenomenon exemplifying group solidarity and effectiveness. It is also a kinetic contest that unfolds differently for each prey and predator species. To see that contest is to see movement capacities and possibilities strikingly displayed such that patterns of movement--certain ways of releasing and spatializing energy--emerge and are clearly distinguishable. There is in fact no reason to think that existing systems of movement notation might not be adapted to record these characters of animal movement and in the end contribute at a very fine analytical level to an index of kinetic domains. Golani's work is clearly suggestive of this possibility (1976, 1982) and so also is Moran's, Fentress's and Golani's (1981).

While the above elaboration of precision- and power-oriented modes of energy release suggests new perspectives and understandings which might enlarge the evolutionary picture, a fuller consideration of ballistic movement will show that the picture might be enhanced even further in respect to upright posture and a diversity of movement. To begin with, on the basis of its inherent temporal shifts, ballistic movement opens up a great spectrum of movement possibilities between sustained and abrupt movement. For example, a blending of projectional qualities is possible such that, rather than being broken into discrete spurts or surges, a projectionally varied movement may emerge in a single continuous dynamic. In other words, it is possible that the projectional qualities shade so finely into one another that a single movement emerges. Thus, in the total movement pattern peculiar to throwing, kicking, and the like, projectional qualities may be and most often are interwoven such that preparatory gestures and follow-throughs enter into a self-contained and self-sustaining dynamic. The movement, rather than being broken up into discrete energy segments, is all of a piece; its flow is unbroken; a single kinetic process is observed. In contrast, if abrupt and sustained movements alone were combined in realizing the spatial pattern, there would actually be, by the very nature of their sharp temporal differences, two

quite distinct forms of energy release, that is, two separate movements. Ballistic movement thus bridges the considerable temporal terrain between sustained and abrupt movement at the same time that it opens up a vast range of possibilities in its own right.

Intensity shifts apparent in ballistic movement are equally significant. They indicate a spatial dialectic at work, one in which the body, in whole or in part, gives itself over to a play of spatial forces and thereby reaps energy spin-offs by partnering itself with space. In these movements, bodily energies and spatially-derived forces come together in a dialectic of control and relinquishment of control. A body's play with space is thus described as an air-borne dialectic. Bounding and sprinting movements are examples and they are certainly not unique to human bodies. As noted earlier, an animal can ride its initial propulsive thrusts in moments of air-borne suspension. All such movements exemplify what is meant by a body's partnering itself with space: momentum makes good the body's initial thrust such that, for the moment, and apart from adjustments to reduce frictional forces, no more need be done for the movement to be carried through. Though not ballistic in nature, soaring and gliding also involve a body's play with space. Thus it should be noted that the dialectic is not unique either to ballistic movement or to humans. Wherever it is at work, however, there is a play between moving and being moved, a dialectic between control and relinquishment of control.

If intensity shifts peculiar to ballistic releases of energy are clearly not exclusive to human movement, then whatever might ultimately be described as the kinetic domain of human creatures, it is not without any relationship to the kinetic domains of other animals. In fact the air-borne dialectic can be used to exemplify how subsidiary structures of a prime taxonomic character of movement--its projectional aspect--are and were shared by different species. A study of comparative movement would likely show that the capacity to integrate bodily and spatial forces in an air-borne dialectic is neither an uncommon nor unremarkable capacity for movement in the animate world.

It might be pointed out in the context of comparative movement studies that a brachiating gibbon is moving ballistically as is a chimpanzee engaged in throwing. That ballistic movement is seen in nonhuman primates should confirm its evolutionary significance. That a spectrum of ballistic movement does not exist in nonhuman primates should also confirm its evolutionary significance. An upright human posture ensures that ballistic movement is possible to the <u>whole</u> moving body, not only its arms, for example, and not only from a single base of support: multiple possible bases of support make ballistic movement a possibility for the whole human body and virtually any of its parts. This means of course that while a single taxonomic character might be observable across several species one cannot thereby assume the global movement to be the same. Neither can one assume that given a certain kinetic character, all possible related movements will thereby be within the province of the animal having that movement character. In short, humans do not brachiate (although they might indeed learn to do so, e.g., gymnasts), gibbons do not skip, and chimpanzees do not punch.

If we now look at ballistic movement more specifically in terms of the evolutionary past, it is possible to suggest ways in which this projectional character might have been of specific selective advantage. For example, while it is apparent that the play of energy in a ballistic movement derives from the power of the initial thrust, it may not be apparent that that play of energy makes it possible to wield power over a larger ground than that of the moving body itself. That is, it may not be obvious that throwing allows the body to interact with the environment at a distance and thus to enlarge its effective sphere or field of influence. As a result, the body need not confront objects directly--whether other animals, food, or whatever--but can act upon them from afar and in consequence, with a built-in measure of safety. In the same way that distance-seeing is connected with upright posture, so what might be called "distance-acting" is similarly connected with upright posture and ultimately with ballistic movement. Here again, however, the movement capacity is not unique to

humans: birds which hurl stones at eggs are also acting at a distance. It is the gamut and complexity of distance-acting possibilities which is peculiar to humans. Differences in range and complexity notwithstanding--and whatever the creature in question--if it is asked what ballistic movement might mean in terms of survival, one could clearly cite actions which augment the effective sphere of a body by increasing the range of its power over its environment. In effect, the kinetic domain of a body is extended beyond its actual boundaries; the spatial, i.e., topological, character of its kinetic domain is radically expanded.

Further advantages are apparent in ballistic movement beyond distance-acting. The limited power orientation of an abrupt movement may be overshadowed by the far greater power possible through ballistic movement, as the difference between hitting and punching or between poking and socking might indicate. By virtue of its built-in momentum and the fact that it may enlist the whole moving body in the projection of force--depending upon the power and range of the movement at the moment of preparation and follow-through--a ballistic release of energy might be momentarily overwhelming or wholly devastating in a combative situation. At the same time, in a combative situation ballistic movement may also keep the body a moving target: by bouncing up and down and by bobbings this way and that, the body is capable of trigger-fast manoeuverings. Agility in the form of both an ever-present readiness to move and a deftness of movement is apparent: human agility and ballistic movement are visibly linked. When ballistic movement is combined with abrupt movement, as it might be in jabbing, for example, or in striking, or when it is combined with sustained movement, as it might be in the preparatory phase of a hurling, or again, of a striking movement, a vast complex of possibilities becomes evident.

The foregoing examination of ballistic movement has shown how an understanding of human evolution could be substantially enriched by a kinetic analysis of stock evolutionary characters such as upright posture. Insofar as the possibility of a rich and subtle diversity of movement is central to a diversity of behavior, there is much to suggest that a complete analysis of movement qua movement would be illuminating in a broad and deep evolutionary sense. Moreover once accomplished, the analysis would open the way toward mapping kinetic domains across the animal kingdom. Such mappings would surely yield new and substantive data on questions of inter-species relationships and human uniqueness.

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1. Motor physiologists use the term, "ballistic," to refer to that kind of movement in which there is no feedback in the period between the initiation and completion of a movement, the hit "target" being the only self-correcting device. There is a correspondence between this usage and the present usage insofar as the concept of control is concerned and insofar as the sheer movement itself is concerned, i.e., in both instances the idea is of a movement which, from the moment of initiation, is self-propelling.

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