Footloose and fossil-free no more: Evolutionary psychology needs archaeology

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Abstract: Evolutionary theories of human cognition should refer to specific times in the primate or hominid past. Though alternative accounts of tool manufacture from Wynn's are possible (e.g., frontal lobe function), Wynn demonstrates the power of archaeology to guide cognitive theories. Many cognitive abilities evolved not in the "Pleistocene hunter-gatherer" context, but earlier, in the context of other patterns of social organization and foraging.

Wynn's target article on cognitive archaeology brings a much needed perspective to research on the evolution of human cognitive mechanisms. Theories in evolutionary psychology often present hypotheses about adaptive pressures that shaped psychological abilities without referring them to specific times in the hominid past. Wynn adds precision to the definition of the "environment of evolutionary adaptedness" (EEA) for spatial cognition and tool manufacture, and questions whether our early Pleistocene ancestors were at all adapted to a hunter-gatherer lifeway. Whether or not Wynn's theory of the cognitive skills required for tool manufacture is correct, his work represents an often-missed step in developing evolutionary theories of cognition. Below, I outline the steps involved in developing such theories, and discuss Wynn's contributions within that framework.

Cosmides and Tooby (1987; 1992) have outlined the usefulness of Marr's (1982) computational theory approach to developing theories of cognition. There are several steps involved:

1. Specify the adaptive function of the computation, that is, what is it that having this cognitive ability allows us to do?
2. Identify the time period during which that adaptive problem existed.
3. Identify the EEA, the relevant selection pressures that prevailed during that time.
4. Propose a set of processes and representations that could serve the identified function. These must be powerful enough to solve the problem.
5. Make predictions about patterns of behavior the proposed computations would generate.
6. Devise tests between alternative theories that could explain the same pattern and one's own computational theory.

Though not subscribing to this framework, Wynn emphasizes the power of using archaeology for steps 2 to 3; in his words, defining the *timing* and *context* of developments in human cognition. Archaeology can also make contributions to the other steps.

For all its emphasis on evolutionary forces, evolutionary psychology seldom discusses the archaeological record of hominid evolution. Wynn shows us why archaeology is necessary. Evolutionary psychologists refer frequently to the EEA for humans, usually characterized as the selection pressures acting on "Pleistocene hunter-gatherers" 2,000,000–10,000 years ago, who are modelled as being like current hunter-gatherers.[1] However, the definition of the EEA for a particular adaptation is the set of selection pressures that occurred while that adaptation was evolving (Tooby & Cosmides 1992); thus not all cognitive mechanisms have the same EEA. Developing a computational theory of the adaptive function of a mental process requires specifying the conditions that prevailed while it was evolving. Knowing those conditions depends on archaeology.

Wynn never uses the term "EEA" but does define the time frames for particular adaptations in spatial cognition, which is crucial for identifying the relevant selection pressures. The period of adaptation for an ability predates appearance of the fully developed ability. Thus, if the spatial skills required for making Mode 1 stone tools are present in other apes, then the EEA for these skills includes conditions present for Miocene apes. (However, the recent finding that crows spontaneously impose shape on tools raises questions about whether this skill is unique to primates; Weir et al. 2002.) The EEA for imposing bilateral symmetry in toolmaking comprises those selection pressures acting on *Homo habilis* and *erectus* 2.5–1.5 million years ago, from when flaked stone tools first appeared to when clear evidence of symmetry appeared. The EEA for imposing more elaborate forms of symmetry includes the changing selection pressures acting on *Homo erectus* and archaic *Homo sapiens* 1.5–0.5 million years ago. *Homo erectus* occupied a wider variety of habitats than earlier hominids – Africa, Asia, Europe (Vekua et al. 2002) – and foraged but did not hunt large game. The major selection pressures acting on *Homo erectus* seem to have been those of foragers moving into new habitats with unfamiliar food resources. Archaic *Homo sapiens,* in contrast, were big game hunters, and faced somewhat different selection pressures.

Wynn wrestles with a difficult problem in doing steps 1 and 4, above. Steps 1 and 4 are related: Knowing the function of this new spatial ability would clarify the necessary representations and processes. Wynn identifies the ability that is of interest: imposing form and symmetry on created objects. However, what adaptive problem does this ability solve? What is the function of imposing symmetry? It is unclear why it was more adaptive to make symmetrical than asymmetrical tools. There is a link between step 1 and steps 2–3: Knowing the context and selection pressures acting during a period of time allows one to specify adaptive function. However, Wynn does not take full advantage of the power of archaeology here. He has done an excellent job of describing the relevant context, yet he does not refer the question of adaptive function to the specific context of *Homo erectus* or archaic *Homo sapiens.* Instead, he considers and rejects adaptive explanations based on preference for symmetry, mate value, and navigation, none of which are problems specific to those time periods. Focusing on the evolutionary context of those species would strengthen his analysis here.

Archaeology can also contribute to steps 5–6, comparing the evolutionarily derived theory to alternative accounts. One alternative theory to Wynn's is that imposition of symmetry depended not on new cognitive abilities, but on manual dexterity absent before 1.5 million years ago. Analysis of muscle attachments on hands and wrists of fossil skeletons could illuminate this. Another possibility is that the necessary spatial skills were already present, but using them for innovations in tool use required greater frontal lobe capacities. I believe domain-general frontal executive functions would be more likely candidates than the more general "associative abilities" Wynn discusses, as unspecified associative abilities fail the solvability criterion of step 4. Anticipating a future need for a tool (Suddendorf & Corballis 1997), planning, and working memory might be the crucial cognitive skills. Here, archaeology and neuroscience together can supply answers. Semendeferi and colleagues showed that parietal cortex, seat of our spatial skills, is not proportionately larger in humans than in other primates relative to body size (Semendeferi & Damasio 2000), whereas the frontal pole, involved in executive function, is disproportionately larger in humans (Semendeferi et al. 2001). Changes in skull morphology that significantly distinguish our species – a domed skull and a less retracted face – allowed more room for the frontal lobes (Lieberman et al. 2002). These two sources of data imply that selection was for frontal lobe abilities, not spatial skills. Analysis of hominid endocasts to determine the extent of key sulci and gyri could also shed light on the relative size of parietal and frontal lobes (Falk 1987).

One of Wynn's most significant contributions is clarifying the evidence that a hunter-gatherer lifestyle did not emerge until 200,000 years ago, that our ancestors were *not* like modern hunter-gatherers. What were they like? Wynn's conclusion that *Homo erectus* did not live in groups because they did not have speech is odd, given the many group-living social primates who lack speech. Like archaic *Homo sapiens, Homo erectus* could have lived in groups, even if those groups lived differently from modern hunter-gatherers. Both species were social foragers facing different adaptive problems.

One conclusion to draw from the recency of hunter-gatherers is that the hunter-gatherer way of life is *the result, not the cause,* of evolution in human psychological mechanisms. Between the emergence of a hunter-gatherer lifestyle 200,000 years ago and the spread of anatomically modern humans out of Africa 80,000 years ago (cf. Capelli et al. 2001; Thorne et al. 1999), only 120,000 years, or 6,300–8,000 generations[2] elapsed. The claim that humans have a large number of psychological adaptations with special design features for anything like the modern hunter-gatherer lifestyle is difficult to reconcile with these numbers.

I hope that collaborations between archaeologists and cognitive psychologists will become more common. The type of task analysis Wynn does for hominid toolmaking over time should be taken as a model for steps 2–3 in characterizing a psychological mechanism. Archaeology can help define adaptive functions for certain abilities by identifying the relevant time and selection pressures. Archaeology can also rid evolutionary psychology of vague assertions about "Pleistocene hunter-gatherers." Spatial cognition, cooperation,[3] living in small groups, and hierarchy negotiation are all adaptive problems that should be referred not to "our hunter-gatherer ancestors," but to earlier time periods, with other patterns of social organization and foraging.

Knowing one's ancestors is centrally important in the mythology of hunter-gatherers all over the world. If evolutionary psychologists really want to take a lesson from hunter-gatherers, we had better start talking to our ancestors. Wynn has shown us one way to do so.

NOTES

1. For example, Buss 1999; Cosmides 1989; Cosmides & Tooby 1987; 1992; Ellis 1992; Kurzban et al. 2001; Silverman et al. 2000; Wright 1994.

2. This assumes generation times ranging from 15–19 years of age (Bogin & Smith 1996; Dean, personal communication, 4/12/02; Dean et al. 2001; Smith & Tompkins 1995).

3. Stone et al. (2002) define the EEA for social exchange as at least as long ago as the Miocene.

Thinking and doing in cognitive archaeology: Giving skill its due

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Abstract: Wynn shows that intentionally standardized artifacts (handaxes) provide evidence of the ability to conceptualize form (symmetry). However, such conceptual ability is not sufficient for the actual production of these forms. Stone knapping is a concrete skill that is acquired in the real world. Appreciation of its perceptual-motor foundations and the broader issues surrounding skill acquisition may lead to further important insights into human cognitive evolution.

Wynn presents a valuable example of the way in which archaeology can contribute to our understanding of human cognitive evolution. Particularly important is his insistence that cognitive archaeologists should avoid traditional archaeological typologies in favor of psychological theories and methods. However, this still leaves the question of *which* psychological theories and methods should be applied.

Insofar as a Grand Unified Theory of human mental life does not appear to be on the horizon, a somewhat pluralistic approach to this question is probably most appropriate (Pickering 2001). The set of theories and methods that proves to be most illuminating will largely depend on what questions are being asked. Wynn chooses to base his analysis of the archaeological record on a fairly traditional theoretical framework derived from cognitive and developmental psychology. This framework is essentially *computational* in that it seeks to explain diverse overt behavior in terms of underlying formal cognitive operations (e.g., "frame independence" or "coordination of shape recognition"). Because Wynn, like many cognitive archaeologists, is primarily interested in using artifacts as evidence of abstract conceptual capacities, this framework is particularly well suited to the questions he is asking.

However, abstract conceptualization is not the only (nor perhaps even the most important) mental process involved in stone tool making, a fact that is reflected in some of Wynn's previous work (e.g., 1993a; 1995). Stone knapping is, first and foremost, a concrete and practical skill that is acquired and performed in the real world. The implications of this for cognitive archaeology are best appreciated from a theoretical perspective that draws on elements of ecological psychology (Gibson 1979; Michaels & Beek 1995), cultural psychology (Bruner 1990; Vygotsky 1978), and the dynamic systems approach (Bernstein 1967; Thelen & Smith 1994).

As Wynn states, "even [the] simplest of knapping actions requires directed blows" (sect. 2.1). In fact, many archaeologists have noted the perceptual-motor skill evident in the earliest stone tools (Ambrose 2001; Ludwig & Harris 1998; Semaw 2000). A great deal of experimental work is needed to describe more rigorously the skills associated with particular prehistoric technologies, but the preliminary PET research (Stout et al. 2000) cited by Wynn does suggest that even simple flake removal places significant demands on the dorsal visuomotor control system (Milner & Goodale 1995) of modern humans. Although perceptual-motor skill is often dismissed as trivial or primitive compared to abstract conceptualization, such skill is an impressive achievement requiring the discovery of dynamically stable behavioral solutions to inherently variable motor problems (Reed & Bril 1996). Huge portions of the modern human brain are involved in this process, including areas like the cerebellum, superior parietal lobule, and premotor cortices that appear to have experienced preferential expansion during human evolution. The sophisticated perceptual-motor skills that typify human sport, art, and craft can take years of dedicated practice to acquire, and are as reflective of human mental uniqueness as more "cognitive" behaviors like visualization and language.

Ethnographic studies of stone knapping (Roux et al. 1995; Stout 2002) indicate that, even in sophisticated modern technologies, mastery of the elementary percussive action is the most fundamental and time-consuming aspect of skill learning. Effective flaking is a specialized form of perception-though-action that allows for the discovery and stabilization of larger scale patterns (strategies) in necessarily variable reduction processes. Less skilled knappers can readily conceptualize or describe an appropriate reduction strategy, but they do not actually *comprehend* it in the concrete sense required for performance.

Wynn has previously pointed out (Wynn 1995) that skilled tool use is only developed through long periods of practice and observation. In modern humans, such learning occurs through guided participation in a *community of practice* (Lave & Wenger 1991). The social situation *scaffolds* (Wood et al. 1976) learning by providing opportunities for participation at appropriate levels of difficulty (i.e., within the *zone of proximal development* [Vygotsky 1978]) using culturally provided material and conceptual tools. Motivational and affective elements critical to learning (Damasio 1994; Greenspan 1996) derive from the culturally constructed meanings (Perret-Clermont et al. 1991; Fogel 1997) of participation. This is exemplified in the modern stone knapping craft of Langda village in Indonesian Irian Jaya (Stout 2002).

Over evolutionary time, this distinctly human, cultural, mode of learning came to replace the primitive hominoid condition. Modern chimpanzee societies scaffold skill acquisition to a degree (Boesch 1991), but lack the added dimension of cultural meaning and structure. In the absence of cultural facilitation of more intensive and/or protracted learning (as seen, for example, in captive "enculturated" apes), efficient nut cracking may approximate the upper limit of skill acquisition possible in chimpanzee soci-