

The evolutionary roots of human hyper-cognition

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Abstract While Professor Pagano's general argument is attractive and may be valid, the Machiavellian intelligence hypothesis that he employs is extremely implausible from a sociobiological perspective. It posits the evolution of massive social inefficiencies in hominin societies over a long period during which there was doubtless severe competition among hominin groups for the same large animal scavenging/hunting niche. I propose an alternative to this part of Pagano's argument that renders his overall theory more plausible. In this alternative, human hyper-cognition is a social good because it supplies powerful and flexible group leadership, which was likely a key element in the evolution of hominin hyper-cognition.

Keywords Human evolution · Lethal weapons · Dominance hierarchy

1 Love, war, and cultures

Ugo Pagano's vast and engaging *Love, war, and cultures* is based on an interpretation of the human brain as the result of sexual selection. But what sort of sexual selection? Here is an excerpt from his paper. Cognitive abilities, says Pagano,

have some positional good aspects... Being endowed with superior language and social skills became essential to find better and more numerous mates. In some respects, one could view our large brain, together with our sophisticated

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consciousness and our complex communication skills, as our own peacock's tail...

Pagano is clear that the origins of human hyper-cognition lie in a preference of females for intelligent but fitness-handicapped mating partners. He writes:

In an initial phase, a large brain... is likely to have been more a liability than an asset... and only a high 'sexual subsidy' was able to make it viable in terms of reproductive success. Until many complementary characteristics, such as development of language and culture, menopause and longer life were developed, a large brain may, like the peacock's tail, have been a disadvantage in terms of natural selection, and it may have shared the characteristics of a pure positional good, with even a negative impact on the overall welfare of the species.

The "positional good" nature of hyper-cognition is in line with the [Byrne and Whiten \(1988\)](#) *Machiavellian intelligence* argument for the expansion of hominin brain size, according to which the large brain is used to socially manipulate group members in a manner that benefits the manipulator at the expense of the manipulated.

While Pagano's general argument is attractive and may be valid, the Machiavellian intelligence hypothesis is extremely implausible from a sociobiological perspective. It posits the evolution of massive social inefficiencies in hominin societies over a long period during which there was doubtless severe competition among hominin groups for the same large animal scavenging/hunting niche. I will propose an alternative to this part of Pagano's argument that renders his overall theory more plausible. In this alternative, human hyper-cognition is a social good because it supplies powerful and flexible group leadership, which was likely a key element in the evolution of hominin hyper-cognition.

2 Runaway sexual selection: the greatest just-so story

Charles Darwin faced many challenges to his theory of evolution by natural selection. Among these, perhaps the most challenging, and certainly the one with the greatest public visibility, was the explanation of human hyper-cognition. *Homo sapiens* evolved for most of its evolutionary history in small hunter-gatherer bands that employed only the most primitive technologies. Nevertheless, brain size increased dramatically over the past 500,000 years of hominin evolutionary history. Moreover, this increase in cognitive capacity was extremely costly in terms of energy usage, required a reorganization of human female birthing physiology, and required giving birth long before brain maturation, thus requiring costly and prolonged early child care.

Alfred Russel Wallace, the co-discoverer of evolution by natural selection, concluded that natural selection cannot account for the evolution of the human brain. Our species, Wallace reasoned, is the product of the "unseen universe of Spirit," which had interceded in the establishment of human hyper-cognition ([Wallace 1864](#)).

Darwin, unwilling to accept a theological explanation, applied his theory of sexual selection, which he considered orthogonal to natural selection, to explain human exceptionalism. [Darwin \(1871\)](#) argues as follows.

The sexual struggle is of two kinds; in the one it is between individuals of the same sex, generally the males, in order to drive away or kill their rivals, the females remaining passive; whilst in the other, the struggle is likewise between the individuals of the same sex, in order to excite or charm those of the opposite sex, generally the females, which no longer remain passive, but select the more agreeable partners.

Darwin's verbal argument was formalized by Fisher (1915, 1930), with Kirkpatrick (1985) and Pomiankowski (1987) later providing complete mathematical models. However, Pomiankowski (1987) showed that the runaway model is tenable only if female mating choice is costless relative to random mating. If female choice is costly, runaway sexual selection cannot evolve.

For an intuitive understanding of the fragility of runaway selection, note that when runaway selection is common in a population, a small group of mutants whose females are unwilling to pay the cost of mating with an exaggerated display male can invade the population, and when established, can in turn be invaded by a mutant male who does not incur the costs of exaggerated display. In the long run, the costly female chooser groups will be competed out of existence.

There can however, be transitory runaway increases in female choice and the preferred male trait. Indeed, there can be continual excursions from equilibrium mate choice based on distinct phenotypic choice (Iwasa and Pomiankowski 1995), and such excursions can give rise to speciation based on phenotypic characteristics (Pomiankowski and Iwasa 1998).

Pomiankowski et al. (1991), however, show that if mutation has a directional bias on the male trait then costly female preferences can be evolutionarily stable. Because most mutations reduce viability, it is plausible to assume that phenotypic traits that indicate high viability will be selected by runaway selection. But in this case, the selection is more directly explained by costly signaling theory: females are willing to pay a cost to mate with males with better genes (Zahavi 1975; Sosis 2000; Bergstrom and Lachmann 2001; Bird et al. 2001; Gintis et al. 2001). Even when not related to difference in viability, mutation pressure on phenotypic traits, particularly exaggerated secondary sexual traits are likely to be biased because random mutations are more likely to degrade rather than enhance their attractiveness.

Even in the case of runaway selection based on a biased mutation rate in an exaggerated male characteristic, it is implausible that such selection be evolutionarily stable when the costs of display are exceptionally high, as in the case of human hyper-cognition. In short, Darwin's answer to Wallace is not at all persuasive, simply because runaway selection in general is unpersuasive when the fitness costs of display are considerable.

3 Sexual selection as social selection

For most sexually reproducing species in which the female gamete is many orders of magnitude larger than the male gamete, the cost of gamete production is much lower for males than females, so it is likely that the male will value the number of copulations more than the quality of each mate's gamete contribution. Moreover, in mammals, the

extent of female contribution to the offspring is generally much higher than that of the male, so this asymmetry is even more pronounced than in other sexually reproducing species. Of course, there are several species where the males care for offspring rather than females, but these are almost exclusively in fish, and less often in birds.

As a result of their greater investment in gamete production and offspring care, females look for males with high quality genes, and males attempt to pass themselves off as having high quality genes. This is an inevitably competitive interaction among males for access to females, and involves a conflict of interest between males and females: the female wants the highest quality sperm, and the male (rare cases excepted) is willing to impregnate females independent of the quality of their genes.

While it is tempting to treat this male/female conflict as independent from evolutionary dynamics, in fact, the typical signaling devices and strategic interactions of the sexes evolves as part of natural selection, and must be analyzed in sociobiological terms. Under normal circumstances, we expect the evolution of social organization in a species to be subject to natural selection, so male/female interactions will be adaptations to the species' environmental conditions. Thus conflict between males and females is likely to shift, under the pressure of selection, from divisive and dissipative forms such as runaway sexual selection to synergistic forms such as costly signaling.

In fact there are no convincing examples of runaway sexual selection in the biological literature, and it is likely that costly signaling accounts for the high rate of male exaggerated traits in some sexually reproducing species (Zahavi 1975, 1995), although sensory selection bias accounts for relatively low-cost displays in some species (Ryan 1998).

Darwin's theory of sexual selection was a serious error, and his account of human hyper-cognition was perhaps the first, and certainly the greatest, just-so story in evolutionary biology (Lewontin 1998).

4 The transition from social dominance hierarchy to leadership by persuasion

Our primate ancestors evolved a complex sociopolitical order based on a *social dominance hierarchy* in multi-male/multi-female groups based on the exercise of physical power by socially dominant males (Shultz et al. 2011). The hominins that split off from the primate line switched from fruit and leaf eating to the scavenging and hunting of large game. This created a niche for hominins in which there was a high return to coordinated, cooperative scavenging (Wrangham and Carmody 2010). This in turn led to the use of stones and spears as lethal weapons, and thence to the reorganization of the upper torso, shoulders, arms and hands to maximize the effectiveness of these weapons, as well as the growth of new neural circuitry allowing the rapid sequencing of bodily movements required for accurate weapon deployment (Calvin 1983).

The availability of lethal weapons in early hominin society undermined the standard social dominance hierarchy of multi-male/multi-female primates. The successful sociopolitical structure that arose from the ashes of social dominance hierarchy was the *reverse dominance hierarchy*, which replaced dominance based on physical force with a political system in which success depended on the ability of leaders to persuade and motivate (Boehm 2000). As documented by Pagano, this system persisted

until cultural changes in the Holocene fostered the accumulation of material wealth, through which it became possible once again to sustain a social dominance hierarchy.

5 The socio-political structure of primate societies

The social structure of multi-male/multi-female ape societies exhibits relatively complex elements that are present in human sociopolitical organization as well (de Waal 1997; Maestripieri 2007). Primates live in groups to thwart potential predators (Alexander 1974), to facilitate the exchange of information as to food location (Eisenberg et al. 1972; Clutton-Brock 1974), and defend food sources against competing groups (Wrangham 1980). There is little need for leadership in such groups. The social dominance hierarchy of multi-male/multi-female primate society thus predominantly channels reproductive privileges and food to the alpha male and his close allies (Vigilant et al. 2001; Maestripieri 2007). Dominant males rarely perform any group-level beneficial acts, except for peace-keeping by intervening in disputes (de Waal 1997).

Males in multi-male/multi-female ape societies rarely provide parenting. Indeed, males and their offspring are unknown to each other in many primate species, including chimpanzees. The alpha male attempts to monopolize access to fertile females but with only partial success, as a considerable fraction of infants have non-alpha-male fathers (Vigilant et al. 2001; Boesch et al. 2006). The alpha male also attempts to control access to food, sharing with the minimum number of political allies that permits him to maintain this control (Boehm and Flack 2010). In short, the political structure of the multi-male/multi-female system is largely a system for funneling fitness-enhancing resources to the apex of a social dominance hierarchy based on physical prowess and coalition-building talent.

6 The preconditions of hominin social sharing

The hominin control of fire cannot be accurately dated, but was doubtless achieved more than 500,000 years ago. This cultural innovation had strong effects on hominin cultural and phylogenetic evolution. Prior to the control of fire, humans almost certainly took to the trees at night like most other primates, as a defense against predators. Because predators have an instinctive fear of fire, the control of fire permitted hominins to abandon tree-living completely. The control of fire was therefore probably a prerequisite for the transition to obligate bipedality (Wrangham and Carmody 2010).

The practice of cooking food was a related cultural innovation with broad gene-culture coevolutionary implications. Cooking presupposes a central location to which the catch is transported, and hence requires abandoning the socially uncoordinated “tolerated theft” distribution of calories typical of food-sharing in non-human primate species, in favor of a distribution based on widely agreed-upon fairness norms. The control of fire and the practice of cooking was thus an important precondition of the emergence of human morality.

In addition, hominins with access to cooked food did not require the large colon characteristic of other primates, which allowed them to reduce the amount of time spent chewing food from the 4–7 h a day characteristic of the great apes, to about 1 h

per day. With a smaller gut, less need for chewing, and more rapid digestion, hominins were liberated to develop their aerobic capacity and perfect their running ability (Wrangham and Carmody 2010).

7 Lethal Weapons and Leadership by Persuasion

Pagano presents a plausible story for the evolution of human hyper-cognition, except that his relies on an early stage of runaway sexual selection where cognition evolves because it allows individual to manipulate and dominate subordinates. This model lacks plausibility, and I have suggested an alternative for this period.

I argue that our primate ancestors evolved a complex sociopolitical order based on a social dominance hierarchy in multi-male/multi-female groups. The emergence of bipedalism in the hominin line, together with environmental developments that made a diet of meat from large animals fitness enhancing, cultural innovation in the domestication of fire, the practices of cooking, and of collective child-rearing created a niche for hominins in which there was a high return to coordinated, cooperative, and competitive scavenging. This in turn led to the use of stones and spears as lethal weapons, and thence to the reorganization of the upper torso, shoulders, arms and hands to maximize the effectiveness of these weapons, as well as the growth of new neural circuitry allowing apid sequencing of bodily movements required for accurate weapon deployment.

The availability of lethal weapons in early hominin society undermined the standard social dominance hierarchy of multi-male/multi-female primates, thus threatening social dissolution, as the hominin niche required sophisticated coordination of collective meat procurement and procedures for the peaceful sharing of meat. A successful sociopolitical structures arose to enhance the flexibility and efficiency of social cooperation in hominins. This was the dominance hierarchy, which replaced social dominance based on physical power with a political system in which success depended on the ability of leaders to persuade and motivate. I contend that this is a more plausible theory of the emergence of high-level cognition and language in *Homo sapiens*.

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