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Comparative Cognitive Science and Convergent Evolution: Humans and Elephants

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Abstract: Comparative cognitive science of humans has tended to overwhelmingly emphasize similarities and differences between humans and other living hominids, particularly chimpanzees and bonobos. In thus under-emphasizing convergent evolution, this skew systematically mis-identifies several crucial explanatory targets, particularly where cultural evolution is concerned. While concentration within the hominid and wider primate lines can tell us much about genetic constraints on human culture and cognition, at least as much attention should be paid to species in which patterns of evolved social cognition respond to problems faced by ancestral hominins. Elephants furnish a first and closest example.

Introduction

A large, multi-disciplinary literature compares human behaviour, cognition, and culture to counterpart species. Of course, these are different dimensions of study, but they are closely related and may be grouped together as *comparative cognitive science*, with the label intended to inherit

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the capacious scope and methodological promiscuity of 'cognitive science'. So wide an enterprise has multiple motivations, including promoting enhanced human empathy with other kinds of animals, but here I will focus strictly on epistemic ones. Given that the human genome is just one recent emanation of a single evolutionary process that generated the actual tree of life, we should expect to find that many phenotypical aspects of humans, including cultural aspects, are partly best explained, and often most rigorously identified in the first place, by reference to differences and similarities with traits and dispositions of other species.

A striking feature of the literature described above is that the overwhelming majority of it compares humans, both ancient and modern, to their nearest genetic relatives, the great apes, and particularly chimpanzees and bonobos. Reasons for this are intuitively clear: it is generally assumed that similarities and differences between them and humans are among our most direct available evidence about development traced through the shared ancestral lineage.

I argue in what follows that while this consideration obviously makes the study of other apes highly relevant to the cognitive science of humans, unsound inferences, and failure to discover some sound ones, can result from the assumption that chimps and bonobos are the extant animals whose cognition and culture necessarily most closely resemble those of humans. This ignores the power of convergent evolution, and disregards the role of ecological problems in generating evolutionary solutions. I will present reasons for anticipating that, in some important respects, an alternative living comparative target, elephants, are a more promising model.

Humans through the prism of chimps

The history of comparisons between humans and chimps (henceforth, for the sake of style, I will take "and bonobos" as implied) is complex and revealing in many of its details, but space here precludes attempting a review. Instead, I will sketch what has evolved as a standard picture, arguably best consolidated in the work of one of its most influential developers, Michael Tomasello. Tomasello (2021) focuses directly on human / chimp comparisons, while Tomasello (2022) provides the wider conceptual framework for organizing the evolution of cognition and culture as mainly supervening on the history of genetic descent in the tree of life. (For reasons the reader will infer, I regard "web" metaphors as preferable to "tree" metaphors here (Mindell 2024); but the older metaphor better characterizes Tomasello's point of view.)

This standard story goes as follows. Exploiting unusually dense frontal cortex, chimps have most of the basic cognitive capacities that humans do, as reflected in ability to solve novel problems using logical and geometric reasoning. Their social emotions resemble likewise resemble human ones, though without mediation through finer discrimination between emotional state types that human language allows. However, the developmental history of a typical human departs from that of a typical chimp in a crucial respect, which generates a cascade of further differences. Specifically, human children, but not chimp children, are keen to assist others in sharing perspectives on observed contingencies that facilitate shared intentionality. This refers to the idea that human groups can share intentions (Bratman 2014), which implies group agency in problem-solving (e.g. "we extract the food from the puzzle box", as opposed to "I extract it and you help"). The drive and capacity to share intentions in turn leads people to deploy significant resources in deliberate pedagogy, both between and within generations (Sterelny 2012), and to use language not just for practical communication about their own preferences and plans, but to construct common complex ontologies, including social ontologies, which they regulate by establishing and strategically modifying social norms.

The standard story leaves some internal questions open. It allows for the possibility that chimps lack cortical circuitry necessary for shared intentions, or alternatively that they lack innate motivation to participate in it. Baby chimps raised in human environments might not acquire such motivation because an egoistic approach to strategic problems can be highly effective in solving those problems, whereas the baby human is often unsatisfied with such solutions because she treats emotions associated with shared agency as basic rewards. Similarly, though Tomasello stresses the importance of the human capacity for 'mindreading' (ability to correctly infer unobservable mental states from observable cues), which he argues considerably out-distances that of chimps, the standard story could instead appeal to 'mindshaping' (Zawidzki 2013), the idea that people converge on shared beliefs and preferences by mutually influencing one another.

The key theme of this standard story, at least for my purpose here, is inference from the fact that chimps are cognitively and culturally egoistic by comparison with people to the hypothesis that such egoism also characterized the earliest humans. Based on this inference, the task of an account of the history of human cognition is to explain how people became hyper-social and norm-governed *within* the ontogeny of the hominin line. This allows for cultural evolution to be given causal precedence, perhaps influencing the human genetic profile via Baldwin effects. The crucial commitment is to the hypothesis that initially egoistic humans became group-centered.

Considering convergent evolution

An alternative basis for comparative cognitive science focuses more on evolutionary convergence (McGhee 2011). This contrast has both positive and negative aspects.

The positive aspect emphasises the transformative *power* of convergent evolution. This is particularly salient in animals with relatively complex brains, due to neural plasticity. West-Eberhard (2003) surveys evidence that, due to such plasticity in mammals and birds, developmental responses, mediated by hormonal regulation and individual learning, to environmental fluctuations at multiple scales often influence the direction of evolutionary change more than adjustments of gene frequencies, including frequencies modulated through epigenetic mechanisms. The weight of plasticity-driven effects relative to gene-driven effects is amplified in environments characterized by unusually rapid rates of climactic volatility. The East African Pleistocene environment in which primates who did not, like chimps, bonobos, and gorillas, colonise forests, was precisely such a site of volatility (Maslin 2017). Due to interactions between northern hemisphere glacial advances and retreats that affected ocean currents around the horn of Africa, and oscillations in the Earth's rotational access that had exaggerated climatic effects near the Equator, the Rift Valley experienced major shifts in the distribution of lakes and vegetation density that fluctuated over cycles as short as 12,500 years. All cortically advanced animals confronting these challenges were under shared pressures to rely on neural plasticity to track the fluctuations. The largest-brained such animals were hominins, baboons, and elephants.

The negative aspect is that relatively small differences in genetic configurations can lead to large differences in cognitive and behavioural characteristics if their evolution is driven by different ratios of environmental pressures to endogenous sources of variation. Forest coverage in Africa shifted considerably over the Pleistocene, but if chimp populations geographically shifted with it, as appears to have been the case, then they effectively anchored their survival on maintaining a stable environmental setting. By contrast, hominin, baboon, and elephant populations surfed the waves of climactic oscillation outside forests. Thus we should expect to find that convergence dynamics – evolution of similar solutions to similar problems across varying genetic platforms – would operate relatively strongly in scrubland variants of different lineages, while driving exaggerated rates of divergence *within* lineages that separated into scrubland and forest populations (Harrison and Ross 2025).

These aspects of variation in convergence prospects and challenges imply caution in making inferences from contemporary cognitive and cultural comparisons of humans and chimps to explanations of the development of *either* kind of animal. By contrast, they invite us to compare human cognitive patterns with those of large-brained animals that passed through the East African Pleistocene volatility together with our ancestors. Baboons are a particularly obvious reference point because they share neural substrate organization with humans.

Among mammal brains, those of primates are distinguished by unusual density of frontal neural cortex. Pioneering work by Herculano-Houzel (2016) and colleagues has shown that in primates *other than non-human apes*, the number of neurons in frontal cortical clusters varies linearly with overall body size. Human brains, as she puts the point, are scaled-up monkey brains. By contrast, the great apes of the forests traded off body size against frontal cortical density: they have more such neurons than smaller monkeys, but lower ratios of these neurons to somatic mass than the general primate template. This is highly suggestive with respect to the weight we should attach, in forming Bayesian priors for selecting research programs, to the anticipated power of environmental variables in comparative cognitive science involving humans. Baboons, by contrast, have about the number of frontal cortical neurons we would expect humans to have if they were half their actual average size. Comparing human and baboon cognition and culture should be expected to cast more direct light on relationships between neural processing power and cognitive expression than comparative studies of humans and chimps.

On the other hand, the strong affinities between human and baboon neural organization make this comparison a less than ideal one for isolating effects of convergence. Patterns of adaptation in both types are canalised along similar pathways by their common cognitive hardware. This confounds clear isolation of effects of problems on the evolution of solutions. We might most efficiently gain epistemic leverage on convergence effects by comparing humans with animals that co-evolved with them through the East African scrubland Pleistocene but adapted to similar pressures using differently structured brains. This exactly describes elephants.

Comparative cognitive science of humans and elephants

The perspective I will promote is not the implausible thesis that elephant social cognition is the closest approximation to that of humans. (I would argue, given more space, that *no* specific animal is the closest such model across all, or even the most important, dimensions.) My point is rather that the elephant / human counterpoint presents a uniquely rich field for comparative cognitive science because of a combination of similar ecological convergence pressures and shared reliance on metabolically expensive brains, but strikingly different neural organization. Over-simplifying for the sake of vividness, we have cases of similar software specs implemented on divergent hardware platforms.

I begin with the common ecological challenges that confronted elephants and early hominins in East Africa. The need to sustain large bodies and brains in semi-arid and changeable scrubland required continuous and long-range mobility in pursuit of food and water. Both hominins and elephants require a range of foods in order to achieve full portfolios of nutrients, precluding mainly opportunistic foraging – group movements required planning and informed decisions. This is the most probable explanation for the fact that hominins and elephants share extremely metabolically expensive brains relative to mammal averages. An additional major cost associated with large brains is slow development. Consequently, hominin and elephant travelling groups almost always included vulnerable, slower-moving, children with relatively low stamina. (Human infants were of course carried.) Both hominins and elephants met this challenge through alloparenting, in which individuals other than the child's mother take active measures to maintain the welfare of children associated with the group (Moss et al 2011). Having similarly expensive brains is likely a core part of the explanation for the similar lifespans and developmental stage durations of hominins and elephants. The need for long-range foraging made both kinds of animals highly peripatetic, and over the course of the Pleistocene hominins and elephants spread from their African origin points across scrubland and prairie environments throughout the world (though until about 40,000 years ago, the global population of elephants far exceeded that of hominins) (Haynes 1991; Gheerbrant 2009).

Alloparenting and the importance of collective planning are the probable basic roots of intense sociality and continuous investment in communication in both humans and elephants. I will not waste space here describing these familiar phenomena in humans. Elephants at close quarters engage in constant rumbling at frequencies below human hearing; these are known to be communicative, as are ear positions and variations in touching with trunk lips that contain as many nerve endings as any sensory interface in either species (Moss et al 2011). Groups at longer distances exchange information through seismic signals detected by special organs in elephants' footpads. Such signals include caller self-identification based on lifelong names that are used most frequently in communication by mothers to young offspring (Pardo et al 2024), exactly replicating the pattern of human name use. Herds of females and young are led by matriarchs and their sisters and adult daughters, with matriarch status being based on track records of successful decisions. Decisions in unusual or pressing conditions involve general deliberation (Moss et al 2011). Bulls form separate herds with looser social structure, with individual males joining matriarchal herds in search of mating opportunities and, on some observed occasions, to visit their mothers (Moss et al 2011). Older females regulate males' access to younger ones, though young females sometimes evade this oversight. Elephant groups are generally stable but complex, with small travelling herds periodically aggregating into larger clan gatherings that can include hundreds of individuals who mutually recognize one another (Moss and Poole 1983; McComb et al 2000; Sukumar 2003). Comings and goings are accompanied by effusive greetings on re-contact, and individuals form long-term friendships that predict intensity of such displays. New births are the events that occasion the most reliable manifestations of collective attention and emotional demonstration, and mothers explicitly introduce calves to clan members who were not present when they were born (Moss et al 2011), and in cases where elephants have formed relationships with specific people, to those individuals. Famously, elephants show intense interest in the remains of dead conspecifics they knew, and travel to the sites of such deaths.

There is considerable theoretical debate across disciplines over what constitutes a 'genuine' norm, but almost all scientists who closely observe elephants endorse the view that they maintain social order by emotionally responding to one another's behavior, rewarding what are perceived as appropriate actions, and socially sanctioning transgressions. For reviews of details, see Moss et al (2011), Bradshaw (2009), Ross (2019), and Wrage et al (2023). A widely reported instance of elephant norm enforcement, almost certainly mediated through but not reducible to hormonal regulation, was observed in several South African reserves where herds of young bulls orphaned by culls committed recurrent lethal violence against rhinoceroses, which ceased almost immediately when older bulls from elsewhere in Africa were introduced to restore normal conduct (Slotow et al 2000; Slotow and van Dyk 2001).

Whereas the human brain follows the standard primate organization at a larger scale, elephant brains have architecture that is unique among mammals. They are significantly larger than is predicted by the overall size of the animal, but this entire difference is accounted for by cerebellum, which contains 10 times the number of neurons found in any other mammal, and to fit within the skull is densely folded in the style of human frontal cortex (Herculano-Houzel 2013). Given the enormous metabolic cost of all these neurons, which require elephants to spend about 80% of their time eating, they clearly have an important function. Efforts to identify this function remain conjectural. In other mammals, cerebellum is associated with regulating movement and orientation of the body in space. The complexity of the elephant's trunk, which combines the functions analogous in humans to the hands, arms, and nose, clearly requires a good deal of 'backstage' control and information integration. But unless the remarkably extended cerebellum plays a role in general cognition, then elephants' capacity for problem solving and rapid learning, near the upper end of the mammal distribution, would be mysterious. Harrison and Ross (2025), based on observations of elephants making difficult choices in experiments designed to elicit their quantitative risk preferences, construct the hypothesis that elephants achieve their unusual stability of episodic memory by correlating records of their body movements and postures with external contingencies – in effect, exploiting somatic memory for general cognition.

Current knowledge allows us only to note that elephant cognition involves higher episodic memory stability than humans generally display, but clearly fall short of humans in generating novel behaviors. We should expect these differences to reflect alternative ways of responding to the common ecological challenges confronted by humans' and elephants' ancestors, which in both cases was handled by maintenance of extravagantly expensive brains. General intelligence is largely a matter of making effective inferences from variations in data, but decades of research in AI has revealed two general styles of information-processing to support such inferences. One style applies relatively fixed and general algorithms to very large data sets. This style requires high-fidelity records, and might be the style that evolved in elephants. The alternative style exploits the power of models, particularly Bayesian ones. It can afford to forget older data as posteriors from Bayesian updating are fed forward as new priors. However, such learning tends to become stuck in local maxima unless the system can experiment with multiple models through running offline simulations. Such imaginative reasoning depends on having many processing units that are relatively distantly connected to points of transduction of external information – as is the case in the dense human frontal cortex.

Reliance on imagination for problem solving carries a major element of risk: the agent may have difficulty remaining anchored in reality. It is hardly a daring conjecture to suggest that this is a recurrent problem for humans, who often reinforce extravagantly false shared beliefs in one another, which then become the basis for collective action. Human cultural evolution developed one useful mitigating technology against this risk, hard external storage of information through drawing, tallying with marks, and eventually writing. (This technology may now be failing us as external storage becomes less hard – that is, increasingly fluid in digital social media.) I speculate that elephants were under no cultural evolutionary pressure to develop such technology, because their superior episodic memories reduced its marginal benefits, and lower imaginative capacity implied by much sparser frontal cortical neurons spared them from a major cost with which humans have had to cope.

Conclusion

The reflections immediately above exemplify the value of the comparative approach to cognitive science. Comparing humans with chimps and other primates is of course useful for identifying inherited constraints on individual cognitive dispositions and capacities. As explained, it shows that our challenge in that regard is not explaining ‘runaway encephalization’ in early humans, as was long supposed, but explaining how humans could become almost as large as gorillas without trading off expensive neural resources. This is obviously important. But once it is accepted that distinctive human cognition is largely social, and that culture has evolved in response to collective challenges, then the most fruitful comparative targets are other highly cooperative animals that faced similar challenges. Elephants – and then more distant analogues such as dolphins – should, I maintain, become at least as widely featured in the study of human cognition and culture as our forest cousins.

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