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Resolving Discontinuity: A Minimalist Distinction between Human and Non-human Minds[1]

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SYNOPSIS. Our genotype is so similar to those of the African apes, and our last common ancestor with them so recent, that it seems impossible that human and non-human cognition should differ qualitatively. But the outputs of human cognition are unique in their limitless creativity and adaptability. Exaption resolves the apparent paradox. Assume that the power to create symbols emerges from stimulus-stimulus linkages and is latent in many animals, and that the structural side of language emerges from the argument structures inherent in the social calculus associated with reciprocal altruism. These adaptations confer the potential for language. However, creating complex messages requires uniquely long-lasting coherence of neural signals, which depends in turn on the large quantities of neurons unique to *Homo*. The only difference between human and non-human minds is that we can sustain longer and more complex trains of thought. All else (emotions, rational processes, even consciousness) could be exactly the same.

To the best of current belief, the hominid line separated from the rest of the primate family not more than 5–7 million years ago. We share with our nearest relatives, the bonobos and chimpanzees, close to 99% of our genetic material. In any other cluster of species with similarly close relations, this degree of closeness would imply that those species were extremely similar, both morphologically and behaviorally. Within such a time-frame, for instance, horses have diverged from one another hardly at all, and even in an evolutionary period ten times as long, changes (apart from a significant increase in overall size) are limited to such things as number of toes and size and shape of teeth (McFadden, 1992). However, leaving aside the not inconsiderable morphological differences between humans and other primates, the behavioral differences are incalculable. While other apes show minor differences from one another in such things as feeding patterns and sexual behavior, human behavior differs dramatically, both qualitatively and quantitatively, not only from that of apes, but from that of any species known to have evolved on earth. Most salient is the distinction in cognition. Countless behaviors involving cognition-complex language, mathematics, music, art, philosophy, research, trade, and all the ancillary behaviors that these entail-appear to lie beyond the capacities of any other species.

This seemingly paradoxical contrast presents a challenge to evolutionary theory that relatively few scholars in the field have faced head-on, a challenge to which even those who have faced it have yet to provide a satisfactory response. Failure to respond has borne ugly fruit, from Wallace's partial apostasy to the current wave of creationist literature. It has left little if any middle ground between the two hitherto-prevailing positions: that humans are so remarkable in their capacities that they could only result from an act of special creations, or that, since humans evolved, the claimed differences between them and other species must be somehow illusory, or of negligible importance compared with the similarities.

Clearly neither position can accord with the facts. Humans certainly evolved, and yet their behavioral differences from other species have placed them in the unparalleled position of being able to determine by

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conscious and deliberate choice whether other species will live or die. We can observe what seem to be massive, qualitative differences in language, in general intelligence, in consciousness, in the ability to plan ahead, and in many other cognitive fields. Yet there has hardly been time for one of these areas to develop independently, let alone several. Moreover, one would expect to find, underlying these cognitive capacities, some significant differences in the organization of the brain, or some novel brain areas not found in other species. But although the allotment of brain areas to the various senses and the organs of motor control varies between humans and their nearest relatives, there appear to be no areas that lack at least homologues in primate species, and no significant differences in patterns of connection (Yeni-Komshian and Benson, 1975; Galaburda and Pandya, 1982; see also Deacon, 1997). Only overall size is a noteworthy variable

The discussion in this symposium focuses on only one of the several differentiating areas mentioned above: consciousness, and whether human consciousness is isomorphic with, disjoint from, or to some extent overlaps animal consciousness. Lack of clarity in the term ‘‘consciousness’’ itself, plus the extremely indirect nature of any evidence that might bear on the issue—not to mention a persisting inability to even agree on what would count as evidence—means that in any gathering of scholars concerned with this topic, disagreement can hardly fail to be both widespread and endemic. But a fundamental question that has to be faced is whether it is even possible to treat consciousness in isolation, without taking up much larger issues.

Essentially there are only two possible scenarios. Either every differentiating human characteristic, our kind of consciousness among them, has evolved separately, with a separate history, separate selective pressures, and separate and distinct adaptations to satisfy those pressure, or else some single factor has intervened, some factor which of its nature would trigger profound changes in all antecedent cognitive capacities.

Ideally, because of the time constraints, one would like to find such a factor, one that would have an origin unambiguously dated to a time between the hominid-pongid split and the present, the consequences of which would impact a variety of precursor capacities in such a way as to generate the entire range of typically human cognitive faculties. The obvious candidate for such a factor is brain size; the human brain's size exceeds that of our nearest relatives by over 300%. What remains unclear, however, is the precise means by which a mere size increase could achieve such effects.

Indeed, the trajectory of human brain development would seem to argue strongly against any significance of brain-size increase per se. During a period from three million to two or three hundred thousand years ago, the hominid brain grew from a size similar to that of contemporary apes to one that falls within the range of modern human variation (Holloway, 1967; Jerison, 1973). Relatively little of this increase in size can be attributed to a concomitant increase in body size (Pilbeam and Gould, 1974). Yet an examination of the fossil record over the same period suggests no equivalent increase in cognitive capacity. The situation was well summed up by Jelinek (1977, p. 15): ‘‘The absence of evidence of innovation and differentiation in the tool forms that can be observed over these prolonged intervals can be taken as evidence against the presence of the conceptual abilities relating to abstraction and synthesis that characterize modern Homo sapiens.’’ If what this suggests is true—that our immediate ancestors were closer to other primates in their cognitive capacities than they are to us—then whatever caused us to become different took place in what for evolution is an eye-blink of time—one two-hundredth of the time it took to produce trivial differences in horses.

However, ‘‘abstraction and synthesis’’ nicely covers just those aspects of human cognition most convincingly implicated in uniquely human behaviors; these are precisely the capacities that underlie language, complex thought (in particular, computations over purely internal stimuli, or ‘‘off-line’’ thought [see Bickerton, 1995]), planning ahead and so on. Could it be that the only difference between humans and non-human species is some hitherto-disregarded consequence of brain expansion that alone makes all of these behaviors possible? Note that while brain size increase is inescapably gradual, such a consequence (call it factor X) cannot be gradual, on the evidence of the fossil record. Consequently, we must conclude that factor X, if not necessarily instantaneous in its effects, must show a very steep gradient of development with sharp threshold effects.

Those who believe in continuity between humans and other species often oppose such factors and express their faith in gradual and continuous change. But those who express such belief simply have not thought through the consequences of that belief in terms of human speciation. For it turns out that what appears to be the straightforward continuist position places a far higher burden on evolutionary processes than does belief in a single catastrophic change.

If there is no single development that accounts for all human-specific traits, then separate evolutionary histories have to be discovered for each and every one of those traits: for language, for our particular brand of consciousness, for the ability to plan ahead, for mathematical and artistic capacities, and so on. Moreover, since the nature of the fossil record discussed in the preceding paragraph suggests that, with regard to all of these characteristics, all of our ancestral species were closer to modern apes than to modern humans, then each of these human-specific traits must have evolved independently within a period of at most two to three hundred thousand years. The evolutionary plausibility of such developments must be close to zero.

The only alternative approach is, as suggested earlier, to hypothesize a single polyfunctional mechanism that could have somehow transformed pre-existing hominid capacities in an extremely short period of time. However, before seeking such an approach, one must first show that there existed, not later than three hundred millennia ago, the necessary foundational capacities that the hypothesized mechanism could have transformed. To do this for the entire range of human-specific cognitive capacities lies clearly beyond the scope of a single article. Accordingly, I shall briefly discuss possible foundations of three key attributes: language, self-consciousness and intelligence.

LANGUAGE

The fact that a number of species including African grey parrots (Pepperberg, 1987), bonobos (Greenfield and Savage-Rumbaugh, 1990), chimpanzees (Premack, 1971) and orangutans (Miles, 1994), can master quasi-linguistic symbolic codes and produce propositional utterances that are structurally similar to human versions of protolanguage, such as pidgin ‘‘languages’’ and the speech of infants (Bickerton, 1990), indicates that the capacity for meaningful use of abstract symbols long predated the emergence of our species. Since adequate output channels (vocal, in the case of parrots; manual, in the case of apes) already exist in these same species, one can only conclude that the only barrier preventing widespread emergence of some form of protolanguage was the absence (except for hominids) of any kind of selective pressure that would have encouraged the spontaneous growth of protolanguage.

Today, the selective pressure responsible for language is widely believed to have been social in nature (Dunbar, 1993; Knight, 1998). Such a belief seems ill-founded in view of the degree of complexity already achieved in the social life of primates (de Waal, 1988; Cheney and Seyfarth, 1990). Moreover, the same social pressures existed in a wide range of primate groups: a pressure that applied only to hominids has to be specified if the uniqueness of language is to be explained. It has been proposed on a variety of grounds (Bickerton, 1990) that some form of protolanguage must have preceded modern syntacticized language. And, needless to say, a protolanguage, whatever its source, would have speedily been co-opted for the social use which today, according to some studies (*e.g.*, Dunbar, 1996), enjoy a statistical superiority to other uses.

Surprisingly, even while dismissing social motivation as primary in the initial emergence of language, one can make a strong case for the grounding in social cognition of the syntax which at a later stage (most probably the emergence of anatomically modern humans, see Bickerton [1990]) was added to protolanguage to yield the natural languages of today. To convert protolanguage into language required moving from an atelic to a telic structural organization. A protolanguage utterance is completed when the speaker has finished saying whatever he wanted to say, regardless of whether any structural requirements are met. A sentence is subject, of course, to the same condition, but also to a further condition,that it is complete only when the required phrases and clauses have been fully assembled. An accumulation of ice-crystals is an atelic structure; a wooden box (with sides, bottom, hinges and lid, all of which have to be in their appointed places if the object is to be classified as a box) is a telic structure.

Whence came the structural units ‘‘phrase’’ and ‘‘clause’’ (the linguistic equivalent of a box’s sides and lid)? While several aspects of primate cognition may be implicated, it seems likeliest that the major factor in their creation arose as a consequence of reciprocal altruism (Trivers, 1971). Reciprocal altruism, widely established among primate species (Goodall, 1986; Smuts, 1987; Strum, 1987; de Waal, 1996) is subject to disruption by cheaters. In order to avoid this, some means of cheater detection must have developed (Tooby and Cosmides, 1992). Since, in the dyadic alliances in which reciprocal altruism is practiced, cheating consists not so much in particular acts but in a pattern of behavior extending over weeks or months, animals must have some means of assessing whether, over time, they obtained from their ally as much as they gave. In order to do this they would have had to determine, for example, how often they groomed their ally as compared with how often their ally groomed them, with similar calculations for food-sharing, support in confrontations, and any other situation in which mutual support might be offered.

One result of this process would be storage, in episodic memory (Moll and Mukulamen, 1997), of the roles performed by each participant in each event. In particular, it would have led to the creation, and differentiation, of Agent or Actor from Goal or Recipient of an action, and of both from Theme or Patient-the substance or individual acted upon. Agent, Goal and Theme are precisely the roles that form the core of argument structure, hence of syntax (see Appendix to Calvin and Bickerton, 2000). Phrases are those groups of words that describe the occupant of one or other of these (and some other ancillary) roles; clauses are the combination of a verb, the descriptor of an action with representatives of the roles which that action involves.

The relationship between reciprocal altruism, roles and syntax is described in detail in Bickerton (1998), Calvin and Bickerton (2000). The strength of the case rests in the fact that it is possible, given obligate role structure as a primitive, to deductively derive all the basic principles of syntax from it. To date, no other mechanism has been described that would similarly yield just those principles and no others.

However, a question immediately arises: if a cheater detection mechanism was already in place, and potentially capable of imposing structure on protolanguage, why did it not immediately become effective and rapidly convert protolanguage into language? In Bickerton (1998) it was proposed that this long delay came about because the areas of the brain subserving cheater detection and protolanguage respectively were initially unconnected. It seems implausible, given the degree of connectivity (direct or indirect) that exists between most brain areas, plus the existence of strong selective pressures favoring linguistic elaboration, that two presumably cortical areas both engaged in cognitive tasks should have remained isolated from one another for so long. A more plausible explanation is to be found in the proposal of Calvin and Bickerton (2000): that there was a ‘‘factor X’’—the capacity of the brain to sustain complex coherent signals over what are (for the brain) significant time periods-and that (as will be shown in subsequent sections) it was this factor that served to delay the onset of fully syntactic language.

INTELLIGENCE

Intelligence is something we all think we can know and recognize, and yet its precise formulation has proved as elusive as has its location in the brain: as Jackendoff (1994, p. 203) admitted, ‘‘unlike language, music or vision, though, we have not been able to show that there are specialized brain areas for conceptual thought.’’ Such admissions reinforce the paradox with which this article opened: that the physical mechanisms of the human brain appear to be continuous with the physical mechanisms of non-human brains (just as Darwinian evolution would predict), and yet the output of human brains differs radically from the outputs of non-human brains.

Without any clear idea of what intelligence consists of, the most parsimonious assumption is that it is non-modular and distributed across the workings of the entire brain (apart from those sections devoted to purely ‘‘housekeeping’’ activities such as regulating blood-flow, breathing, and other autonomic functions). For instance, it has been proposed by McPhail (1987) that there are only three intelligence levels: one represented by animals that can link stimulus and response (‘‘S-R animals’’), one represented by animals that can link stimulus with stimulus (‘‘S-S animals’’) and one represented solely by humans. Such a position by no means commits one to Skinnerian behaviorism; the reason why operant conditioning fails to inculcate in any animal any behavior that exceeds that animal’s biological capacity is that all species differ in the range and type of phenomena over which S-R and S-S operations can function. According to McPhail, it is these differences of type and range that account for the apparent scala natura of intelligence, for the fact that most of us would regard, say, frogs as less intelligent than dogs. But frogs and dogs, both S-S animals, may differ not in their relative intelligence so much as the kinds of thing, and the sheer number of things, with which they can interact in an intelligent manner.

If McPhail’s analysis is correct (and no compelling counterevidence seems to have appeared in the decade since it was made) then only humans have an advantage in intelligence over other animals. But whence does this intelligence derive? A strong case was made by McPhail (see also Bickerton, 1995) that language was the source. If indeed language derived from prior cognitive rather than prior communicational systems, as proposed by (*inter alia*) Wilkins and Wakefield (1995), Ulbaek (1998), Bickerton (1990) (but see Hockett and Ascher [1962] and Carstairs-McCarthy [1999] for alternative views), then a linguistic source can be strongly argued for. However, the independence from language of (at least some kinds of) complex thought has been argued by Churchland (1984), Donald (1991, 1995) and many others. Widespread too is the belief that some kind of ‘‘language of thought’’ (Fodor, 1975) underlies and serves to organize human cognition, and that this language of thought is somehow different from, and anterior to, overt language. On this view (one that seems to be reinforced by introspection) we ‘‘have a thought’’ and then clothe that thought in the appropriate words.

However, suppose there was some ‘‘tertium quid,’’ some factor distinct from both language and (human-type) intelligence, yet without which neither language nor intelligence could function. Instead of hesitating, like Buridan’s ass, between two relatively unappetizing alternatives—‘‘humans got language and therefore became intelligent’’ and ‘‘humans became intelligent and therefore got language’’—we could then say ‘‘humans got factor X and because of that became capable of both language and intelligence.’’

From an evolutionary perspective, this third option has numerous advantages. We do not have to seek individual evolutionary explanations for language and intelligence (let alone all the other human-specific differences). Indeed we do not have to seek explanations for language and intelligence, period. With regard to language, all the necessary pieces were in place long before our species made its appearance; they simply lacked a device that would make those pieces usable as language.

But what about intelligence? Does what I am saying entail that humans have no more innate intelligence than all other vertebrates (and even some invertebrates); that is, S-S capacity? Yes it does. On such a view (and with one exception) humans would differ from chimpanzees only to the extent and in the way that dog differ from frogs: whatever intelligence they had would range over a wider domain. That exception is, of course, factor X (which might incidentally be at least partly responsible for the breadth of range just mentioned). In other words, factor X would yield both quantitative and qualitative increments in both language and thought.

CONSCIOUSNESS

Of the triad of disproportionate human/nonhuman differences to be discussed here, consciousness is without doubt the most slippery. It might seem as though the only way of knowing whether any individual has a consciousness like ours (or indeed any kind of consciousness at all) is by verbal report. But even with verbal reporting, we cannot know whether the subjective experience of another is the same as ours, any more that others can know if our experience truly resembles theirs; for instance, what we regard as ‘‘green’’ could give them the subjective experience we derive from ‘‘red,’’ and vice versa. This, known to philosophers as the ‘‘other minds’’ problem, has so far failed to achieve any generally-accepted solution.

If we cannot even demonstrate that fellow-members of our own species are conscious in the same way that we are, it must of necessity be even more difficult to determine the degree and nature of subjective consciousness experienced by non-human species. Given the limitations of methods of inquiry available to date, determining the extent of consciousness in other species can employ only extremely indirect methods. We may infer consciousness, as does Griffin (1992), from a number of different types of evidence: from pre-linguistic communication strategies and devices, from problem-solving, from the performance of tasks that seem to involve concept formation, from the production and use of functional artefacts, and in particular from the capacity to carry out acts of deception that seem to imply an awareness of the thoughts and emotions of conspecifics.

The latter area, relating to what is known as ‘‘theory of mind,’’ has enjoyed much attention in recent years. An animal would be said to have a theory of mind if it could be shown that that animal was aware that other animals had knowledge and that such knowledge could differ from its own. Evidence as to whether other animals have a theory of mind is inconclusive, with some field studies (*e.g.*, Whiten and Byrne, 1988) suggesting that at least some apes do and some experimental studies (*e.g.*, Povinelli, 1994, 1996) suggesting that they do not (see Jolly [1991] and Hayes [1998] for critical discussion of this issue). Since on similar evidence small children seem to have the same limitations as apes, it is unclear whether a theory of mind is a prerequisite for language, as Dennett (1982) assumes, or whether a theory of mind grows out of having language. While some assumptions about what other people know have to be built into our own utterances (for instance, in English we must decide between the articles ‘‘a/an’’ or ‘‘the’’ based on our assumptions as to whether a particular referent is known to our interlocutor or not), it could equally well be argued that what holds in modern languages did not necessarily hold in the earliest languages (let alone protolanguage) and that only through millennia of trial and error could humans have learned that the content of others’ minds might differ from their own.

However, even if the latter point is conceded, there can be little doubt that many animals possess the necessary infrastructure for a theory of mind, including intentional acts of deception (Whiten and Byrne, 1988). Moreover, while the presence of a theory of mind necessarily implies a consciousness much like our own (since knowledge that the contents of others’ minds can differ from ours entails that we know what the contents of ours are), the absence of such a theory does not necessarily mean an absence of consciousness. Natsoulas (1978), among others, has pointed out that consciousness is used in several senses and that it is not, of its nature, a unitary concept. While at least one level of consciousness (consciousness-2, in terms of Bickerton [1995], which appears equivalent to Natsoulas's ''Consciousness 4'') seems to be derived linguistically, this form of consciousness (''being aware of . . . one's own perception, thought or other occurrent mental episode'' [Natsoulas, 1978, p. 911]) is perhaps only the visible ninth part of an invisible iceberg of consciousness—consciousness OF a pain, a loud sound, the color red, the presence of a nearby predator, consciousness THAT it is raining, X is one's sibling, one has a pain in one's right big toe, and so on.

As Griffin (1984, pp. 218–232) showed in a thoughtful review of ''ape language'' experiments, the outputs of trained apes, though falling far short of human language attainment, do at least tell us about the desires of those apes in a way that renders it unlikely that such behavior is an unconscious reflex. After all, the moving around of magnetic counters on a board can hardly be classed among instinctive activities, and a proposition is a volitional act—there are no circumstances, either for humans or trained apes, in which a particular utterance, and no other, must be produced.

If one took what at first sight seems the most parsimonious view of things, it might still seem possible to deny any measure of consciousness to the ape who ''says,'' for example, ''Me want orange.'' Such a view might contend that the ape has no concept of what it is ''saying,'' nor any conscious awareness of the fact that it wants an orange. On this account, hunger would simply trigger a learned behavior that in the past had been reinforced by offers of food. The fact that it said ''Me want orange'' rather than ''Me want banana'' could then be attributed to mere chance, both would have yielded food, in past experience. However, since ''linguistically''-trained apes are well able to discriminate between oranges and bananas, responding to each with the appropriate sign, it goes against the grain to suppose that a preference is not involved and that by saying ''Me want orange'' the ape does not also imply, ''I know that I want X and that X is an orange.'' The uniquely human dimension (being able to think something like, ''Well, here's me telling that dumb trainer again what he surely ought to know'') may be lacking, but the rest of consciousness could still be there.

Whatever the case, we need to look a little more closely at parsimony. As some participants in the present symposium pointed out (see for instance Cartmill, 2000) the notorious Morgan's Canon (Morgan, 1894) which precludes us from positing a ''higher'' cause for any behavior when a ''lower'' cause would suffice, is often invoked as an example of parsimony, but in fact is nothing of the kind. One consequence of the canon is that, if it is systematically adopted, we are left with a mountain of traits and behaviors that have to be attributed solely to humans and for each of which, accordingly, a separate evolutionary origin and history (all compressed into the last few hundred thousand years) has to be produced. We might therefore reasonably conclude that, overall, the most parsimonious approach involves attributing to other animals any ''higher'' cognitive capacities for which there is evidence that would convince us if the subject in question were a human one.

If a child, for instance, were to say ''Me want orange,'' few researchers, outside of hardcore behaviorists, would assume that the child's autonomic system had directly triggered a learned behavior that had been selectively reinforced, all without any form of consciousness on the part of the child. Although it is almost as difficult to interrogate human two-year-olds as it is to interrogate chimpanzees, most researchers would ''look in the back of the book,'' so to speak, for the answer. Knowing that the child would eventually become just like us, they would not hesitate to attribute to it all the faculties that we possess, even if perhaps in embryonic form. Given the overall continuity of nature, it sees ill-advised to apply a double standard where non-humans are concerned.

FACTOR X

If indeed other animals, or at least some other primates, have a set of capacities that a single factor might conceivably transform into modern human attributes, what could such a factor be? Brain size alone cannot serve for several reasons. For one, as noted above, brain sizes of individual hominids began to fall within the range of modern human variability over a million years ago, without any concomitant changes in human behavior; indeed, brain size tripled from ape levels without any really significant changes at all. For another, to say ''Humans are the way they are because they have bigger brains'' explains nothing. We still have no explanation of how a purely quantitative development could bring about qualitative changes; nothing that we currently know of the brain supports such a development, and much of what we know seems to argue against it.

However, the ballooning of the brain could still be regarded as the most salient factor distinguishing hominids from other primates, so one might reasonably look for some quality ultimately dependant upon brain size. Such a quality could not result from the addition of new brain areas, since as Deacon (1997) has shown, the human brain has added no new areas to the ape brain, and indeed (apart from size) differs from that brain only in the relative sizes of certain functional areas. Factor X could, however, consist in some change in the mode of operation of the brain, a change for which increase in brain size was a necessary if not a sufficient prerequisite.

Let us begin by asking if there is a common factor among the things only humans can do that is not shared by any of the things other animals do. Note to begin with that the things only humans can do are not only high-flown things like mathematics and philosophy, nor are they limited to things for which language is a prerequisite. They include things like tap-dancing, rhythmic drumming, representational drawing, doing jigsaw puzzles and playing simple games the rules of which can be ostensively, rather than verbally taught. What do such tasks require? Common to all of them, the superficially simple as well as the complex, is the maintenance, over what in terms of brain activity are long periods, of coherent patterns of neural signaling that are neither necessarily stimulated or necessarily supported by stimuli from the external world.

More strikingly still, it would appear that none of the many behaviors which, in contrast with the foregoing, we share with other animals requires the maintenance of similar patterns. Most if not all of such behaviors involve reacting to external stimuli and do not require maintenance of a coherent signal over such long periods; indeed, it is likely that the level of coherence required falls considerably short of what is demanded by the construction of complex sentences.

Activity in animal brains generally is maintained through sensory inputs through which the animal can monitor its environment-inputs that may or may not directly trigger motor (re)action. These inputs are filtered by three attention networks described in Posner and Rothbart (1992). The anterior network detects events, the posterior network orients to sensory stimuli, while the vigilance network maintains consistent levels of attentiveness over time. At least the first two of these networks have a focusing effect: ''When one attends to a location in visual space, not only is information at that location increased in processing efficiency, but informaton at other locations is reduced over what it would be if attention had not been paid to the selected location'' (Posner and Rothbart, 1992, p. 93). In other words, an animal's effective functioning depends as much on its capacity to control and suppress externally triggered ''irrelevant'' stimuli.

What remains unclear in this and many other treatments is how attention networks function when stimuli are internally triggered. At least half a billion years of evolution have selected for mechanisms that would sort through the constant bombardment of sensory stimuli that all organisms experience and select from among them precisely those stimuli that had to be attended to—that brought with them life-enhancing or life-threatening possibilities. In other words, if there ever were animals whose attention was as likely to be fixed on the random motions of leaves in the wind as on a predator rapidly approaching them, such animals would long since have disappeared.

But such mechanisms are powerless to determine which of a potentially infinite number of internally generated stimuli require attention. None of them may, in the short run at least, appear to be any more deserving of attention than any other. Yet the brain cannot attend to all of them, any more than it can attend to all external stimuli. The consequence, as some perceptive writers have suggested (*e.g.,* Dennett, 1991; Calvin, 1996*a, b*) have suggested, can only be some kind of Darwinian competition between the neuronal firing patterns that represent possible ideas or sentences. And since in this competition there are no evolutionary guidelines or preferential positions, the competition can only be decided by brute force, and victory can only go to the pattern that recruits the most neurons to support it.

A further consideration supports this claim. All neural signals, in common with signals generally, are subject to decay in transmission. The longer the distance they travel, the more they require to be merged or combined with other signals, the greater is the likelihood that their coherence will deteriorate. Calvin, (1996*a, b*) has proposed that a number of hominid behaviors (*e.g.*, hunting by aimed throwing, percussive hammering to produce stone tools) required a very precise timing of neural impulses—a precision which (certainly in the case of aimed throwing) had to increase geometrically as range increased arithmetically. Timing, however, presents a peculiar problem. If impulses do not synchronize, a thrower will miss the narrow ‘‘launch window,’’ the appropriate moment of release required for that throw to be effective. But if only two or three neurons control the throwing, the chances that they will not synchronize exactly are high, just as the chances are high that in a small group of singers, one singer out of time or out of tune will spoil the harmony of the group. Conversely, however, the average of a large number of neurons firing (more or less) synchronously will yield a stable and precisely timed action, just as a large choir, despite the presence of some members not entirely in time or in tune, will yield a harmonic result. Thus the selective pressures involved in throwing and similar non-cognitive behaviors could have increased the number of neurons potentially available for cognitive operations.

However, it would also do considerably more than this. A brain capable of recruiting large ensembles of neurons could to a large extent overcome the problems arising from purely intra-cerebral activities; recall that these problems involved competition between alternative mental acts where there were no clear evolutionary guidelines, and maintenance of a coherent, complex signal unsupported by external stimuli. Recruitment to an ensemble of sufficient numbers of ‘‘spare’’ cells (that is, cells that might otherwise take part in, but were not exclusively dedicated to, other activities) would enable the spatiotemporal firing pattern of that ensemble both to overcome competing ensembles and to maintain that pattern at a high level of coherence despite the absence of supporting stimuli from the environment. It would, in other words, permit that autonomous life of the mind—unhooked from any necessary extra-cerebral causes or effects—familiar to all of us from our own subjective experience (see Calvin [1996*a, b*] and Calvin and Bickerton [2000], for a fuller discussion of these proposals).

It should be made clear that the foregoing scenario for the development of typically human cognitive behaviors is still to a large extent hypothetical. However, no current knowledge in the field of neurophysiology seems opposed to it, and it explains much about the evolution of humans and their relation to other animals that alternative explanations leave mysterious. It explains, for example, how so radical a gulf between the capacities of humans and other animals could have formed in so short a time. For although the increasing number of neurons occurred gradually, the attainment of adequate coherence levels had to show a sharp threshold effect. Let us assume that, as proposed by Kayne (1994) and assumed by Chomsky (1995) and many other syntacticians, sentences are created by the progressive binary combination of morphemes, and let us assume, since the ‘‘language of thought’’ must have a syntax of some kind (Fodor, 1975), the same applies to any conscious, directed thinking, whether uttered or not. Since the loci of concepts that must be linked (regardless of whether the final output is a spoken sentence or an unspoken thought) are scattered over a wide area of the brain (Ojeman, 1991), signal coherence must be maintained through a whole series of ‘‘merges’’ (as these binary linkages are named in linguistics). Whatever level is required to sustain a single merge, brain capacity must then increase by 100% in order to produce two merges, yielding structures of a mere three units (maximum possible, four units). Having reached this level, however, an increment of 50% (three merges) will yield structures of four to eight units, while a further increment of only 33% (four merges) will be sufficient for four merges, yielding five to sixteen units, and an additional 16.5% (five merges) for six to thirty-two units.

Thus, while the onset of the capacity to merge single concepts into larger wholes would develop extremely slowly in its early stages, once past the two-to-three merge level progress would be very rapid indeed, accounting for the relatively sudden emergence of a species with capacities exceeding those of all other species. Note further that, if this hypothesis is correct, it explains what is perhaps the most salient (and the most mysterious) fact about human evolution: that the hominid brain grew for several million years without, apparently, any concomitant change in human behavior such as one would expect from a substantial change in cognitive capacity, and yet achieved massive cognitive gains without any concomitant increase in size–indeed, modern human brains are slightly smaller than those of Neanderthals.

BACK TO CONSCIOUSNESS

Let us now consider the consequences of the foregoing approach for the nature of animal consciousness. If an increase in the ability to maintain coherence in neural signals over longer time periods is the only difference between the brains of humans and those of other animals, it follows that the difference between human and animal consciousness cannot be large.

Indeed, it would seem that the most significant difference is most probably limited to what one might call discursive consciousness: that is, the capacity to maintain, ‘‘trains of thought,’’ volitional and purposefully directed strings of ideas that are fully accessible to consciousness. Discursive consciousness is what enables humans to plan future actions, review past actions, and consciously modify their behavior. While it is of course impossible to prove that other animals do not also behave in this way, the power that such a capacity confers, a power to radically and continually modify both individual and species behavior without concomitant genetic change, is surely what is most directly responsible for the many differences between the way humans live and the way other animals live. If any other species shared this capacity with us, we would expect such a species to begin building shelters, using fire, exterminating species that predated upon it, creating novel artefacts, or executing at least some of the behaviors hitherto associated exclusively with humans or their immediate ancestors. It is implausible that members of any species would possess such a capacity, even in embryo, and not use that capacity to enhance their own fitness.

Perhaps the only other significant difference would arise from a factor which itself is a product of increased signal coherence: language. As discussed in Bickerton (1995), the necessity of linguistic labels for oneself (‘‘I,’’ ‘‘me’’) entailed by the necessary existence of other words signifying one’s interlocutor(s) (‘‘you’’) or the topics of discourse (‘‘he,’’ ‘‘she,’’ ‘‘they’’ etc.), would quickly lead to a reification of the individual as the central actor in what Dennett (1991) described as the ‘‘Cartesian theater’’: ‘‘I think that. . . ,’’ ‘‘I believe that. . . ,’’ ‘‘It seems to me that. . . ’’) and to the ‘‘self’’ element in ‘‘self-consciousness’’ that enables one to detach oneself from one’s own actions and to think thoughts such as, ‘‘Here I am being polite to so-and-so even though I despise him, what a hypocrite I am’’ This is by no means to suggest that other animals lack a clear awareness of other individuals and, by extension, of themselves as entities similar to those other individuals. It is merely that the addition of discursive consciousness and language to such awareness makes it possible for us to construct narratives about ourselves and to be simultaneously aware of both what we are presently doing and what we think about what we are doing.

Apart from discursive consciousness and the reification of self, it seems highly likely that our consciousness is identical with that of other animals. That is, we would be subjectively aware of our experience in exactly the same way. Animals would be conscious of what philosophers call ‘‘qualia’’—the redness of a rose, the sweetness of a lump of sugar—in just the same way that we are; they would experience pain, hunger, thirst just as we do; they would have a similar subjective experience of emotions like fear, anger, sorrow while the constant bombardment of sensory stimuli all animals receive and filter appropriately would appear to them (allowing for differences, in some cases, of sensory modalities) much as it does to us. If such is indeed the case, it would seem to have significant implications for the ways in which we feel about, and behave towards, other species.

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