Do Extraterrestrials Have Sex (and Intelligence)?

JEROME H. BARKOW

Department of Sociology and Social Anthropology, Dalhousie University, Halifax, Nova Scotia,Canada B3H3J5

ABSTRACT: This thought experiment addresses the range of possible evolved psychologies likely to be associated with extraterrestrial (ET) intelligence. The analysis rests on: (1) a number of assumptions shared by the SETI project; (2) recent arguments concerning convergent evolution; and (3) current theories of how intelligence evolved in our own species. It concludes that, regardless of how and which cognitive abilities arise initially, extraterrestrially they can develop into intelligence only if an amplification process involving a form of predation and/or sexual selection occurs. Depending on the amplification process, ETs may be xenophobic; however, it is more probable that they will be ethnocentric. Their ideas of reciprocity and fairness are likely to at least overlap with our own. They will definitely be culture-bearing and probably have two sexes, both of which are intelligent. Regardless of the degree of physical similarity of ETs to ourselves, convergence makes it likely that we will at least find their evolved psychology similar enough to our own for comprehension.

Let us pretend that a science fiction scenario suddenly becomes real. We establish contact with extraterrestrials. Immediately, scientists, journalists, and Pentagon officials have a list of questions. The Security Council of the United Nations wants to know whether the extraterrestrials are xenophobic and interested only in destroying us, or whether they see us as potential friends and allies. Do they have hidden Machiavellian agendas? Is there a basis for diplomacy? The journalists begin by asking whether the extraterrestrials have sexes and, if so, how many. The natural scientists want to know the extraterrestrials' biology and technology, while the anthropologists are asking whether they have culture. Entrepreneurs are wondering whether we can appreciate one another's arts and crafts and entertainment. The questions are endless.

Let us conduct a thought experiment in order to narrow our questions and perhaps develop some tentative answers. Its goal will be to distinguish between the possible and the impossible, the probable and the improbable. The modus operandi will be to begin by taking a look at how our own psychology most likely evolved, then to consider variations on these scenarios, variations that could produce an evolutionary psychology different from our own. In short, in this thought experiment we are exploring alternative evolutionary routes that potentially lead to a species different from ourselves, but which we nevertheless would recognize as intelligent. To avoid disputes over the meaning of "intelligent," let us define that term operationally as "the ability to visit or otherwise contact us."

Thought experiments begin with assumptions. Our essential assumptions are that there is life on other planets, and that in some cases it will be intelligent (as defined above).

IS THERE LIFE ON OTHER PLANETS AND, IF SO, IS IT INTELLIGENT?

This issue has received considerable attention in recent years from astronomers and others. The existence of Earth-like planets elsewhere in the universe, the evolution of life on those planets, and the possibility of that life's developing intelligence have been dealt with by Carl Sagan, Francis Drake, Amir Aczel, and others.[1–7, 8] (p. 150) From 1992 to 1993 the United States financed a Search for Extraterrestrial Intelligence (SE TI). What was actually being searched for were radio transmissions from extraterrestrials. SETI continues to the present time, although since 1993 it has been privately financed. The search has now expanded to include an effort to detect flashes of laser light that could represent the attempts of extraterrestrials to communicate with us.[9]

Amir Aczel's[8] recent book typifies the optimism of SETI supporters; his title, *Probability 1*, telegraphs his conclusions:

> The probability of extraterrestrial life is 1.00, or a number that for all purposes is 1.00. We are not alone. And while we haven't seen anyone from outside our planet yet, and while the distances to the stars are so dauntingly immense, someday in the future there might be contact.[8] (p. 215)

Aczel's arguments are rooted in astronomy, physics, chemistry, and probability theory, and even summarizing his thinking would be beyond the scope of this paper (which is primarily concerned with evolutionary psychology). Nevertheless, his work and that of his predecessors certainly justifies a thought experiment based on the assumption that, yes, there is life out there on other planets.

But even if there were life, would it be intelligent life? Aczel continues to be entirely confident. "Given enough millions of years from the time the DNA molecule arrives or evolves on a planet, intelligence will inevitably be the ultimate outcome."[8] (p. 150) Here we must pause, for Aczel has now strayed into evolutionary biology, and at least one prominent evolutionist would not agree with him.

Stephen J. Gould, in his well-known study of the Burgess Shale faunas, *Wonderful Life,*[10] argues that there was nothing inevitable or even likely about the evolution of intelligence even on our own planet. For Gould, if one were to "rewind the tape of life" and replay it, we probably would have a very different evolutionary history. Gould has long argued that evolution is a matter of "contingency," and tends to deemphasize the roles of natural selection and adaptation. Ultimately, for Gould, the evolution of so unlikely a trait as "intelligence" is as much a matter of pure chance as anything else. As Simon Conway Morris[11] puts it, Gould's "argument, largely using the Burgess Shale faunas, was that the range of variation in the Cambrian was so huge and the end results in terms of the diversity of today's world so restricted that the history could be regarded as one colossal lottery."

Fortunately for our thought experiment, Morris's recent book, *The Crucible of Creation: The Burgess Shale and the Rise of Animals*, gives us strong grounds for disagreeing with Gould. Where Gould emphasizes contingency, Morris focuses on *convergence*, convergent evolution in particular: "Put simply, contingency is inevitable, but unremarkable. It need not provoke discussion, because it matters not. There are not an unlimited number of ways of doing something. For all its exuberance, the forms of life are restricted and channelled."[11] (p. 12), [13] (pp. 203–204) Morris persuasively reminds us of how frequently we find convergent evolution producing similar forms from dissimilar lineages. In part, he convinces us with examples. There is the 65-million-year-old South American marsupial strikingly similar to the much more recent—and placental—sabre-toothed tiger.[11] (pp. 203–204) There are the two varieties of moles, each a tunneling animal with short and powerful digging forelimbs and poor eyesight, but which, in spite of appearances, are related only by convergent evolution, one being a placental mammal and the other a marsupial. He discusses the similarities of the wings of birds and bats. He convinces us of his main point, that "again and again we have evidence of biological forms stumbling on the same solution to a problem."[11] (p. 204) The problems to which Morris refers are adaptive problems, reminding one of the argument of evolutionary psychology that our psychological traits evolved as solutions to adaptive problems. But before we move on to evolutionary psychology, let us first make explicit the relevance of Morris's convergence argument to the evolution of intelligence on other planets.

For Morris, if Gould's "tape of life" were to be replayed, we might well get different species from different lineages, but we would also meet with many familiar forms and behaviors. Let us move that tape to another planet, one that supports life. Here, too, the argument from convergent evolution implies that we would still meet with many familiar forms. We recall that Aczel and his predecessors conclude that there are an immense number of planets bearing life; if so, it seems inevitable that some extraterrestrial species would have faced adaptive problems similar to those faced by our own ancestors. If convergence is the rule then in some of these species evolution must have produced intelligent beings. This assumption, crucial to the present task, seems warranted. Now we are ready to return to our main question about the nature of those intelligent beings.

THE ENVIRONMENT OF EVOLUTIONARY ADAPTEDNESS

What environment gave rise to the selection pressures that produced the intelligence and cultural capacity of our own species? It was the environment of our ancestors, that is, their *environment of evolutionary adaptedness*, the EEA. To understand the evolution of extraterrestrial intelligence, therefore, we need only begin with a clear picture of our own EEA, suggest reasonable changes in that early environment, and discuss the likely evolutionary psychology of a species that evolved in this altered EEA.

Unfortunately, the EEA question is perhaps the weakest aspect of evolutionary psychology.[12] There was no single EEA—we evolved over millions of years and across much geography, so that our environment of evolutionary adaptedness would have varied across both time and place.[13] Moreover, there is a growing consensus that much of human cognitive capacity is, in fact, shared by the anthropoid apes,[14–17] and may have been shared by our common ancestors. In short, different aspects of our intelligence probably first evolved during different periods of time.

The EEA problem does not seem to have hindered the development of a robust and data-based evolutionary psychology. After all, in that field a wrong reconstruction of the EEA is likely to produce a hypothesis that is simply invalid, and careful research will presumably reveal this. If my picture of the EEA involves our having evolved primarily as hunters rather than gatherers and cultivators, but my empirical research shows that, transculturally, most children love to collect and to cultivate rather than to watch animals and play at throwing projectiles, then perhaps it is time for me to rethink my picture of the EEA.[18,a] Unfortunately for the present effort, thought experiments cannot be corrected so readily.

If there was no single EEA for our own species, presumably there was no single EEA for our extraterrestrials. However, as Charles Crawford[18] points out, we can distinguish between the EEA of a species and the EEA of a particular adaptation. William Irons[19] comes to much the same conclusion in his argument that we should replace the concept of the "environment of evolutionary adaptedness" (EEA) with that of the "adaptively relevant environment," or ARE. "Relevant" here refers to "relevant to a specific adaptation." The approach Crawford and Irons take permits us to focus not on the totality of the EEAs of a species, but on specific traits and clusters of traits. Thus, we can talk about a component or kind of intelligence and ask about the kind of environment in which this specific trait would have conferred an adaptive advantage—would have led individuals with this characteristic to have a fitness advantage over others. This approach is clearly artificial in that an adaptation exists not in isolation, but in interaction with all other existing adaptations, while the totality of adaptations themselves interact with and alter their environment in what Laland *et al.*[20] term "niche construction." The notion of an identifiable "adaptively relevant environment" clearly represents a considerable simplification, but let us accept it heuristically.

With the Irons and Crawford approach, we need not seek to recreate the entire EEA of our extraterrestrials. Rather, we can specify psychological mechanisms or traits and the AREs in which they would have been adaptive. This strategy permits us to begin.

XENOPHOBIA AND ETHNOCENTRISM

Will our extraterrestrials wish to annihilate us, or otherwise hate and fear us? That will depend on the ARE we posit. For example, Alexander and others[21–29] have suggested that our intelligence and cultural capacity evolved as the result of a self or auto-predation process. Bands of our ancestors would, in effect, have culled one another of the stupid, the slow to be able to make and use tools well, the individuals unable to grasp basic hunting/raiding/defending strategy, and the ones who failed to cooperate with other band members in the face of external threat. This culling process would have selected for individuals with more rather than less intelligence, tool (weapons)-making skills, and ability to communicate and cooperate with others.

[a]For a full discussion of the nature of evolutionary psychology hypotheses and a refutation of the argument that they are unfalsifiable, see Ketelaar, T. and B.J. Ellis. 2000. Are evolutionary explanations unfalsifiable? Evolutionary psychology and the Lakatosian philosophy of science. Psychological Inquiry **11:** 1–21.

Even as a predator may, by culling the slow-of-foot, cause its prey to evolve fleetness, we may have been our own predator, causing our species to evolve intelligence.

For our extraterrestrials, let us alter this scenario from self-predation to *co-predation* or *inter-species rivalry.* Suppose they evolved in company with a closely competing species. Each species would have culled the other of the dull, uncooperative, and uncommunicative. Each species would have supplied the environment (or at least the ARE) in which intelligence was adaptive. Each species, too, would necessarily have been selected for automatic hostility towards the other. Perhaps, in the end, only one of these antagonistic species survived.

Suppose that we now meet such an extraterrestrial species, one whose intelligence is a product of co-predation. If we in any way trigger their automatic hostility to rival species, we may find ourselves with a xenophobic and even genocidal enemy. In such a case, the only way to avoid conflict would be for us to find some way to convince the extraterrestrials that we are in some sense the same species that they are, their siblings rather than the enemy. Of course, this will not necessarily be possible. We should also ask why such a species would have a project analogous to SETI in the first place. Presumably, their SETI would be looking for external threats rather than for a cooperative exchange of information with another species. If contact comes not from radio waves or laser pulses but because either they or we actually develop some form of interstellar travel, we should expect them either to attack us or to flee from us.

Suppose, however, that the extraterrestrials evolved with self-predation, as we ourselves likely did, so that the conflict and culling that led to their intelligence was much the same as those of our own ancestors. In that case, we should expect the extraterrestrials to be not xenophobic but ethnocentric. They are therefore likely to react as we do to external threat, by increasing in-group solidarity and cooperativeness, and with a ready hostility towards other groups. They are also likely to readily assume that they are intrinsically superior to us. We ourselves would presumably react ethnocentrically to such an extraterrestrial species, suggesting that our relationship with them would potentially be tense but open to the possibilities of diplomacy and alliance.

Finally, let us suppose that the intelligence of our extraterrestrials was the product of neither predation nor self-predation but of another process entirely, such as tool-using. If so, they might exhibit neither xenophobia nor ethnocentrism. The question is: could tool use lead to intelligence? It seems unlikely that any ecological adaptation, including that of tool use, could result in intelligence without a subsequent *amplifying process*. Self-predation and co-predation are possible amplifying processes, but so is *sexual selection*. However, sexual selection can only occur in a species that has sex.

WILL EXTRATERRESTRIALS HAVE SEX?

Why Two Sexes?[b]

Why do we have two sexes? Why not none, or three? As we did with the question of whether there is life on other planets, let us rely on some of the experts in this field. This time, however, we get no single answer. The standard account of the two-sex problem (often associated with George Williams)[30] has been that having two sexes increases the efficiency of natural selection—rather like shuffling the deck frequently increases the probability of a "winning hand." In this case, a "winning hand" refers to having offspring with a set of genes well adapted to the current ecology. Because ecology continually changes, adaptation requires that genetic change track ecological change. This tracking occurs more quickly if the organism's set of genes, including new mutations, is continually "shuffled" or rearranged. However, Barton and Charlesworth,[31] in a recent review article of the two-sexes problem, find that this argument is valid only if a number of assumptions (including assumptions about mutation rates) are made, otherwise the faster adaptation is offset by the fact that the genetic recombination—the reshuffling—also breaks up winning hands, that is, already existing adaptive sets of genes.[31] (p. 1988)

A more recent answer to the two-sexes problem, also discussed by Barton and Charlesworth, has to do with the effects of parasites. Parasites tend to have a shorter life span than do their host species. With only one sex, the host's longer time between generations means that it cannot evolve defenses against the parasite as fast as the parasite can evolve advantages. When the host has two sexes, however, an offspring's defenses against parasites may differ from those of the parental generation, reducing the parasite's advantage. The result is a never-ending co-evolutionary, reciprocal positive feedback process in which the adaptations of the parasite drive selection for resistant adaptations in the host, and in which the host's resistant adaptations in turn drive selection for adaptations in the parasite. However, though they are sympathetic to this model, Barton and Charlesworth find that it rests on a crucial technical assumption that does not necessarily obtain in all cases (the assumption that "sex does increase additive fitness variance").[31] (p. 1987)

Finally, having two sexes permits a species to rid itself of deleterious mutations. With one sex, such mutations tend to accumulate because offspring are generally identical to their parents. With two sexes, offspring vary from one another and from their parents so that those individuals with a lower load of deleterious alleles outreproduce those with a larger load. Thus, the two-sexed species rids itself of harmful mutations at a higher rate than does the species with only one sex. This advantage, however, depends on assumptions about mutation rates and the proportion of existing deleterious alleles.[31,32]

Sexual reproduction with two sexes comes at a substantial cost. Whereas for an asexual species offspring have 100 percent of a parent's genes, with two sexes this proportion is halved. Presumably, this cost is more than offset by the various likely advantages already discussed. But if two sexes are good, why not three? The answer is that the more sexes, the greater the degree of dilution of the parental genes; apparently, with more than two sexes the dilution is not offset by whatever advantages multiple sexes might bring.[31]

Barton and Charlesworth[31] conclude their review of the various routes by which two sexes may originate and be maintained by pointing out that the various alternative hypotheses are not mutually exclusive, but that their relative importance remains

[b]For an excellent introduction to the problem of sex, including the "why two sexes" question, see Science **281:** 1979–2008, "The evolution of sex." Geary[32] (pp. 15–21) also provides a useful summary of the arguments about sexes, as does D. M. Buss. 1999. Evolutionary Psychology: The New Science of the Mind. : 100–103. Allyn & Bacon. Needham Heights, MA.

to be determined. This conclusion is more than adequate for present purposes: if there may be multiple routes for the evolution and maintenance of two sexes under varying circumstances, it is reasonable for us to assume that at least some extraterrestrials do have two, but most likely only two sexes. Two sexes mean that sexual selection is possible: Would sexual selection have played a role in the evolution of the intelligence of extraterrestrials?

SEXUAL SELECTION

Having two sexes means that each parent contributes a gamete. Each gamete has one half of the genes of its parent. A new organism is formed—reproduction takes place—when one gamete combines with another. Producing a gamete requires an expenditure of energy termed by Trivers[33] "parental investment." One sex will typically invest more in its gametes and subsequently in the entire reproductive process than will the other. By convention, the sex that provides the greater parental investment is called "female," while the sex that provides less investment is termed "male." Trivers argues that the sex with the greater parental investment will be more discriminating in selecting a mate than is the sex with the lesser investment, so that members of the latter sex compete with one another for access to the former. Usually, though not always, it is the female that provides the greater investment.[c]

Sexual selection, "the processes associated with mate choice and competition for mates,"[32] (p. 20) explains much of animal morphology and behavior. For example, in some species males compete for females, with the winners producing most of the next generation. In such a species whatever morphology or behavior increases a male's chance of winning will be selected for. In elephant seals, for example, it will be sheer size coupled with aggressiveness towards other males. The result is that the males are far larger than the females. In deer, where stags contest using their antlers, sexual selection favors enormous racks of antlers, despite their considerable energetic cost. In other species, sexual selection may be primarily about female choice. A female may select the male who appears to have the "best genes." If bright plumage is a sign of "good genes" (in the sense of resistance to parasites, in particular), then selection will present us with a peacock's tail feathers. "Runaway" sexual selection may hypertrophy a particular trait. But let us look at the human situation.

Discussion of sexual selection usually focuses on the sexual dimorphisms it produces. This is especially true in the case of human beings, for whom there exists a large and controversial literature on sex differences in evolved psychology.[d] However, for present purposes we need to focus not on the differences between the sexes produced by sexual selection but on the similarities.

In a 37-country survey, David Buss[34] found that both women and men, when asked to rank 13 traits for desirability in a long-term mate, ranked intelligence sec-

[c]See Trivers[32] (pp. 215-218) for examples of species in which, despite the female's initially greater investment in the gamete, it is the male that provides the greater overall proportion of parental investment. In such species it is the male and not the female that is the more discriminating in selecting a mate. For an excellent introduction to sexual selection, see Cronin, H. 1991. The Ant and The Peacock: Altruism and Sexual Selection from Darwin to Today. Press Syndicate of the University of Cambridge. Cambridge, England.

ond. (Interestingly, "kindness and understanding" were ranked first.) There is a growing consensus among evolutionists that sexual selection was a crucial process in the development of human intelligence (for examples see Refs. 13, 32, and 35). This conclusion is not surprising, as it is likely that a mate's intelligence increases the ability to provide parental investment. "Intelligent" activities likely to have increased the potential parental investment of a partner in the course of human evolution would include skill in tool- and weapon-making, skill in fire-making, in processing of foodstuffs, in locating food sources, in cooperating with others to gain food (as in a cooperative hunt), in conveying foodstuffs to a place of safety (such as a home camp), in caring for offspring, in protecting oneself and others from injury, in finding or making shelter, in learning from others, in communicating and in being sensitive to the communications of others, in paying attention to the environment, in being able to influence the behavior of others—and no doubt in many more ways. In our own species, sexual selection clearly strengthened selection for intelligence and for possible indicators of intelligence. It may well be, if Buss's respondents behave in real life the way that they rank items in a paper-and-pencil test, that sexual selection for intelligence continues today.

Both in our own species and likely for our intelligent extraterrestrials, sexual selection would have acted as an amplifier for intelligence, *regardless of the nature of the earlier selection pressures that had initially led to the relevant cognitive capacities*. In short, diverse early selection pressures for various cognitive abilities, once amplified by sexual selection, could have had a similar result: intelligence. For example, for our own species there is a body of opinion that argues that tool use, a trait we share with our close relative the chimpanzee, was one of the major selection pressures for cognitive abilities, linked both to the origins of human language and to sexual selection.[e] Tools may have been particularly useful, among early hominids, in extracting food from nuts and from bones. Even when tools are not used, primates require a considerable and varied cognitive set of abilities to obtain food.[14] (p. 179–184) Given sexual selection, from such beginnings may have come intelligence and language.[f] Our extraterrestrials, however, may owe their initial cognitive abilities to

[d] See, for example: Symons, D. 1979. The Evolution of Human Sexuality. Oxford University Press. New York; Daly, M. & M. Wilson. 1984. Sex, Evolution and Behavior, 2nd ed. Willard Grant. Boston, MA; Ellis, B. J. 1992. The evolution of sexual attraction: evaluative mechanisms in women. *In* The Adapted Mind: Evolutionary Psychology and the Generation of Culture. J.H. Barkow, L. Cosmides and J. Tooby, Eds.: 267–288. Oxford University Press. New York; Buss, D. M. 1994. The Evolution of Desire. Basic Books, New York; Symons, D. 1995. Beauty is in the adaptations of the beholder: the evolutionary psychology of human female sexual attractiveness. *In* Sexual Nature, Sexual Culture. P.R. Abramson and S.D. Pinkerton, Eds.: 80–118. University of Chicago Press. Chicago; Geary[32]; and Angier, N. 1999. Woman: An Intimate Geography. Houghton-Mifflin. Boston, MA.

[e] See, for example: Parker, S. T. & K. R. Gibson. 1979. A developmental model for the evolution of language and intelligence in early hominids. Behav. Brain Sci. **2:** 367–408; Parker, S. T. 1985. A social-technological model for the evolution of language. Curr. Anthropology **27:** 671–739; Gibson, K. R. 1986. Cognition, brain size and the extraction of embedded food resources. *In* Primate Ontogeny, Cognitive and Social Behaviour. J. G. Else and P. C. Lee, Eds.: 93–105. Cambridge University Press. Cambridge, England; Gibson, K. R. & T. Ingold. 1993. Tools, Language and Cognition in Human Evolution. Cambridge University Press. Cambridge, England; McGrew, W. C. 1995. Thumbs, tools and early humans. Science **268:** 586; Mellars, P. & K. R. Gibson. 1996. Modelling the Early Human Mind. Cambridge University Press. Cambridge, England.

an ecology entirely different from our own, such as the problems posed by a pelagic environment. In their case, too, however, sexual selection may have amplified these abilities into intelligence.

What of the dimorphisms often (though not necessarily) produced by sexual selection—the antlers, the brilliant plumage, the huge size that we see in some species? Could it happen that, on an extraterrestrial world, sexual selection has produced an intelligent species in which one sex also has, say, large tusks or bright fur? Could it be that extraterrestrial males will be much larger than their females, as with elephant seals? The fact that elephant seals are not intelligent adumbrates the answer to these rhetorical questions.

Sexual selection for two or more energetically expensive traits would presumably weaken selection for each of them. Large brains are very costly for an organism to produce and maintain: it is difficult to envisage a successful species being selected both for large brains and for another costly trait, such as the annual growth and shedding of antlers. However, energetically less costly attributes, such as bright coloration, could probably evolve along with intelligence. Alternatively, we might discover an only fairly intelligent species with only fairly large antlers. In such a case we would have to do the discovering, as presumably an only "fairly intelligent" species (one that would not actually be intelligent by the working definition of intelligence we are using) would not be capable of interstellar communication or travel.

Could sexual selection produce radically sexually dimorphic intelligence? For our own species there is considerable controversy over whether we have a slight degree of sexual dimorphism in some cognitive abilities[32] (pp. 312–313): Is it possible that, for our extraterrestrials, the dimorphism will be so great that only one sex will be intelligent? For example, let us assume that the males use their intelligence to form tool-using coalitions that compete with other coalitions in herding females: Could it be that males but not females would be sexually selected for tool use and cooperation, so that ultimately the males but not the females became intelligent? The simple answer is "no." As Miller[35] points out, linkage between the two sexes means that what is selected for in one tends to appear automatically in the other. Dimorphism in intelligence would require it to be maladaptive for one of the sexes, and it is difficult to imagine a scenario in which this would be so. Sexual dimorphism in intelligence is not the same as dimorphism in, for example, antlers. Antlers and intelligence are both very costly, but while large antlers increase the male's reproductive success, intelligence increases the reproductive success of both females and males. Intelligent females presumably gain an adaptive advantage in terms of greater ability in food acquisition and processing, better care of offspring, and perhaps social transmission of information to them, and so forth. Moreover, if our extraterrestrials were at all like baboons, females and lower-ranking males would use intelligence (in the form of social manipulation) to copulate despite the efforts of the dominant male.[36] It seems very unlikely that there could be intelligent males without intelligent females.

Could the extraterrestrials have intelligent *females* but unintelligent *males*? Suppose the males have specialized in a sexual competition feature such as size, so that

[f]Barton and Dunbar,[16] (pp. 257–258) dispute that ecological problems, including food strategies involving extraction, could have led to intelligence. They argue strongly, instead, for the importance of the processing of social information.

sexual selection favored very large bodies but not large brains. Brains being very costly, sexual selection might favor the males who sacrificed brain for body mass. Let us further assume that the females were selected for intelligence because their small size forced them to make tools and cooperate with one another in order to get food. The result would apparently be small but bright females and large-bodied but dull males. This scenario, too, is unlikely. If the females are more intelligent than the males, will they not find ways to copulate with the more intelligent even if not necessarily dominant males, as in the already-mentioned case of baboons? For our extraterrestrials, it seems most probable that, in the end, both sexes would be selecting one another for intelligence.

SOCIAL INTELLIGENCE AND THE SENSE OF JUSTICE

Will extraterrestrials share our ideas of fairness and justice? A sense of justice is an aspect of what, for our own species, has been called *social* intelligence. The nature of social intelligence, in turn, depends on the evolutionary bases of social cooperation of a species. We therefore must discuss social intelligence and cooperation before examining the sense of justice.

SOCIAL INTELLIGENCE

Rather than having been selected for intelligence because it enabled them to use tools or to be more effective at foraging or hunting, our ancestors may have been selected for intelligence because it led to their success in social competition. In recent years this approach (often associated with Humphrey[37,38]) has become part of a family of arguments linked to the notion of "Machiavellian" intelligence.[39] The term connotes deceit and manipulation, but has now become, in the words of Whiten and Byrne[40](p. 1), a "*banner*" for hypotheses that imply that "possession of the cognitive capability we call 'intelligence' is linked with social living and the problems of complexity" [italics in original].

Success in social competition may involve (among other abilities) skill in deceiving others and in detecting the attempts of others to deceive one. It is not, however, always in one's genetic interests to cheat or deceive: it depends in part on the evolutionary basis of social cooperation.

SOCIAL BASES OF COOPERATION: NEPOTISM

For many species, including our own, kinship is one of the bases for social cooperation. Essentially, cooperating with and aiding kin is a likely way to increase one's own genetic representation in the gene pool. Parental care, for example, involves the parent's investing in an organism that shares one half of its genes. We show similar care and altruism towards other relatives as well. As Richard Dawkins[41] has made clear, genes that lead their bearers to act in such a way that the duplicates of these genes in other carriers are favored will thereby increase in the gene pool. Nepotism and parental care, therefore, are readily understandable in evolutionary terms. Note, however, that for nepotistic behavior to evolve it must mirror the equations of population genetics: Aid should be given to others in proportion to the probability that they do indeed share one's genes. Moreover, the recipient's chances of reproducing (reproductive value) and/or aiding other relatives also needs to be taken into account, as well as the probability that the donor, in giving aid to others, is jeopardizing his/her own ability to reproduce successfully. Where nepotism is the sole basis of cooperation, therefore, there are only three types of deception that will benefit an individual: deception about degree of kinship to a potential aid donor, deception about the value of the aid for the recipient, and deception about the likely cost of the aid to the donor. Thus, if our extraterrestrials have evolved social intelligence on the basis of cooperation among kin, they may deceptively assure us that we and they are closely related; or they may expect us to make such a claim and may treat our denial of kinship as an indication that we do not desire to have a relationship with them. Note, however, that this kind of kin selection for cooperation and social intelligence does not appear to require the evolution of any sense of justice or fairness. (Selection for nepotism seems more likely to result in the evolution of mechanisms to determine degree of kinship, such as recognition of familial scents or distinctive family features.)

Suppose, however, that our extraterrestrials disperse at birth, or hatch like tadpoles with no contact with their parents and no means of detecting siblings: Under these conditions we cannot expect selection for social intelligence and cooperation based on nepotism. If intelligence and cooperation nevertheless do evolve in such a species, its basis most likely would be *reciprocal altruism*.

SOCIAL BASES OF COOPERATION: RECIPROCAL ALTRUISM

Reciprocal altruism[42] is one route to the evolution of cooperation among non-kin. Although non-kin by definition do not bear an above-average proportion of one's own genes, with reciprocal altruism aid donated is likely to be repaid so that aiding another is in effect aiding oneself. Even more than in the case of nepotism, however, proffering aid entails the risk of being cheated. The individual who accepts aid but fails to return it or returns scant measure will clearly have an adaptive advantage over the individual who never "cheats." In spite of this risk, reciprocal altruism is so advantageous that cheating leads not to selection against reciprocal altruism *per se,* but rather to the evolution of mechanisms that detect or otherwise discourage cheating. In human beings, these mechanisms apparently have to do with a sense of fairness, of justice and ethics and morality.[g]

[g]Trivers[42]; L. Cosmides. 1989. The logic of social exchange: has natural selection shaped how humans reason? Studies with the Wason selection task. Cognition **31:** 186–276; Irons, W. 1991. How did morality evolve? Zygon: J. Religion & Sci. **26:** 49–89; R. D. Masters & M. Gruter. 1992. The Sense of Justice: Biological Foundations of Law. Sage Publications. Newbury Park, CA; Nitecki, M.H. & D.V. Nitecki. 1993. Evolutionary Ethics. State University of New York. Albany, NY; Arnhart, L. 1995. The New Darwinian Naturalism. Am. Polit. Sci. Rev. **89:** 389–400; Corning, P.A. 1996. Evolution and ethics: an idea whose time has come? (Part I). J. Soc. Evol. Systems **19:** 277–285; Thiessen, D. 1996. Bittersweet Destiny: The Stormy Evolution of Human Behavior. Transaction Publishers. New Brunswick, NJ; De Waal.[16]

Anthropologist Donald E. Brown[43] (p. 139) includes reciprocity as a "key element" in all human moral systems. Underlying these systems is an emotion having to do with our judgments about fairness and justice. McGuire[44] speaks of *moralistic aggression*, defined as "anger and retaliatory thoughts in response to another's failure to reciprocate prior helping." Moralistic aggression is a capacity we share with the chimpanzee. de Waal[45] tells us that chimpanzees have a "sense of social regularity," which, he suggests, "may be a precursor of the sense of justice." This precursor is "a set of expectations about the way in which oneself (or others) should be treated and how resources should be divided, a deviation from which expectations to one's (or the other's) disadvantage evokes a negative reaction, most commonly protest in subordinate individuals and punishment in dominant individuals." For reciprocally altruistic species, selection for social intelligence and cooperation has meant selection for the mechanisms and emotions underlying systems of morality and ethics.

If the social cooperation of extraterrestrials is based at least in part on reciprocal altruism, then their social intelligence will necessarily include either ideas of justice and fairness or else their functional equivalent. Most likely, their notions of obligation and reciprocity will overlap with our own, and they will probably be capable of moralistic aggression. *Warning*: because the sense of justice is an evolved mechanism to minimize cheating, it follows that extraterrestrials that share our ideas of fairness will also share our tendencies towards both sharp practice and deception.

SOCIAL BASES OF COOPERATION: FEAR

Could there be a social intelligence originating neither in nepotism nor in reciprocity but in *fear*? Our working definition of intelligence presupposes the capacity to accumulate and transmit huge quantities of knowledge: fear tends to constrict information flow, as we will see, so that it is difficult to envisage social organization based on fear producing a high level of technology. Nevertheless, let us explore the consequences of social intelligence and cooperation based on fear.

Michael Chance[46, 47] has distinguished between hedonic and agonistic modes of attention and social organization in primates. Chimpanzees have social inequality, but the highest-ranking individuals are not the most aggressive but the most socially skilled, who thereby benefit from alliances/friendships and strategic sharing. Chimpanzee social organization is therefore largely hedonic. In contrast, macaques have agonistic social structures, social structures based largely on fear. Frans de Waal[16] (who has had long experience observing both macaques and chimpanzees) comes to a similar conclusion, one emphasizing the relative tolerance of high-rank chimpanzees compared to high-rank macaques.

These differences in attention structure have important implications for communication and for social intelligence. The social intelligence of a species with agonistic attention structure necessarily focuses on how to influence the behavior of others through threat and appeasement, thereby constricting communication and cooperation. A hedonic attention species, however, may be expected to have a much broader flow of information among individuals[48] and a wider basis for cooperation. In particular, hedonic attention structure species would presumably be far more likely than agonistic attention structure species to develop elaborate systems of cooperation based on reciprocal altruism.

Let us now return to our extraterrestrials. If their social intelligence and cooperation are largely agonistic in nature, then we should expect reciprocal altruism to be relatively underdeveloped. They therefore would lack our own sense of justice and quite likely would be unable to understand our concepts of ethics and fairness. The basis of our relationship with them would be one of mutual threats and intimidation. Fortunately, it seems unlikely that we would find such a species: Their narrow and agonistic social intelligence would probably not permit them to develop the complex forms of social cooperation and immense accumulation of technological knowledge needed for interstellar contact.

WILL THE EXTRATERRESTRIALS HAVE CULTURE?

As a social-cultural anthropologist, I find the question of whether extraterrestrials will have culture especially consequential. By "have culture," I mean whether they are heavily dependent on an accumulation of socially transmitted information. In this context, "a culture" is an information pool from which individuals select, enter, and edit items.[13] While psychologists have paid much attention to individual cognition, for the social-cultural anthropologist the most salient trait (other than language) that distinguishes human from nonhuman primates is that humans accumulate and socially transmit far larger stores of information (culture). Will our extraterrestrials be similar to us, in this regard?

The extent to which a species is selected for individual learning and intelligence, rather than reliance on socially transmitted information, is a matter of the rate of change of the local ecology. Boyd and Richerson[49,50] have discussed the circumstances under which social transmission of information, as opposed to individual learning, is favored. In a very slowly changing environment, selection favors neither type of learning but instead itself tracks change, adapting the organism's behavior to its environment. In contrast, an environment that changes too rapidly for natural selection to track selects for a capacity for individual learning. But suppose we have an environment whose rate of change falls between these poles—it is too fast for genetic adaptation, too slow to require continual individual learning: The result is a species that relies on *social* learning, particularly learning from parents, while retaining a capacity for at least some individual learning.

Let us take the example of what Paul Rozin[51] has termed "the omnivore's dilemma … the great advantage of discovering a new source of nutrition, versus the danger of ingesting a toxin." In a stable (moderate change) environment, socially transmitted information is likely to be comprehensive and reliable; the omnivore is best off relying on social learning rather than on an individual learning process that risks the ingestion of toxins. In a more rapidly changing environment, however, old food sources may become scarce and new plants and animals may appear. In this situation, the omnivore is likely to be selected for greater reliance on individual learning, despite its risks. To generalize: When the environment is reasonably stable over long periods of time, then selection will favor the capacity to accumulate and transmit information from generation to generation; where it undergoes prolonged change at a rate too rapid for its tracking by natural selection (or when the species repeatedly changes habitats), it is independent learning that will be favored. (Rapid change would also favor horizontal or within-generation learning, as opposed to vertical or between-generation learning.)

If a rapidly changing environment leads to selection for individual learning and intelligence, could we not find extraterrestrials who, while capable of prodigious individual learning, do not rely heavily on accumulated, socially transmitted information? Could such a culture-free species contact us? Probably not. An extraterrestrial individual would have to independently invent in a single generation the full panoply of scientific and engineering information, as well as the industries required to fabricate the components needed for contact. Indeed, that individual would first have to conceive of the idea of life on other planets! Even given the existence of an extremely long-lived species of unimaginably vast intelligence, it seems unlikely that such an individual could or would devote itself to a SETI-like project. We are obliged to conclude that any intelligent extraterrestrial species would have a society in which, at a minimum, vast amounts of technical information can accumulate and be socially transmitted. Extraterrestrials will be culture-bearing.

Our own culture-bearing species has developed many distinct societies with overlapping but distinct information pools. We should therefore not be surprised to find that the extraterrestrials also have multiple cultures.

DISCUSSION

The EEA and Emergents

The modus operandi of this thought experiment has been to look at specific environments and selection pressures one at a time, despite the fact that the EEAs of a species vary both in time and in space. Evolution is always a sort of resultant-of-forces calculation—many selection pressures operate simultaneously, and their sequencing and interactions are liable to be very important. The result of this process has been, in our own species, an extraordinarily complex intelligence. As Gibson[52] puts it, "the fundamental foundations of modern human cognition rest, not upon one specific ability, such as language or symbolism, but rather upon a highly plastic, environmentally responsive 'biocultural' brain and a suite of interacting, mutually reinforcing neurological capacities each of which is present in rudimentary form in other animals, but greatly expanded in our own species." Intelligence does not evolve in terms of one trait and one selection pressure at a time. Worse, human intelligence—and perhaps self-awareness—could be emergents from multiple selection pressures acting in a particular sequence. There is no way to model such emergents in extraterrestrials, given how poorly understood they are for our own species.

Amplifiers

The co-predation, auto-predation, and sexual selection processes are important amplifiers in understanding the evolution of intelligence. They represent reciprocal positive feedback loops that can greatly expand intelligence. However, "intelligence" is not a black box, and we need to think about what specific abilities and psychological traits would be amplified by each of these processes. For our own species, it is quite likely that both autopredation and sexual selection were involved in the generation of our complex evolutionary psychology, and it would be useful to compare the traits that each of these processes would likely most affect.

It is perhaps worth noting that, if we are wrong about our extraterrestrials having sex, they would necessarily have developed intelligence through an amplifying process involving either auto-predation or co-predation. Thus, a single-sex intelligence would be either xenophobic or ethnocentric. Evolution is a slower process for a one-sex species than it is for a species with two sexes: the predation process would have required an extremely long time period to amplify cognitive abilities into intelligence, implying an exceedingly stable ecology.

Group Selection

Could it be that our extraterrestrials will have reached intelligence through a form of group selection in which the evolutionary unit is neither gene nor individual but the group? Cultural group selection, for example, may have been involved in human evolution.[13,50] Group selection continues to be discussed,[53,54] and it would be useful to explore group selection scenarios that could lead to extraterrestrial intelligence.

This thought experiment could readily be broadened. For example, we could well ask whether extraterrestrials and we will share a sense of esthetics. Orians and Heerwagen[55] apply habitat selection theory to landscape esthetics: Applying it to extraterrestrials might help us to determine whether they would have, for example, any desire to possess our planet (or even to be tourists on it). It would also be interesting to explore whether the extraterrestrials would have our type of self-awareness. Finally, this experiment has deliberately neglected the important topic of language. Extraterrestrials who rely on socially transmitted information must have a form of communication, whether acoustic, visual, tactile, electromagnetic or chemical (the last including taste, smell, and pheromone transmission).

CONCLUSIONS

The results of this thought experiment are obviously provisional: Different assumptions would yield different conclusions. Still, it does appear that if we are not quite in the Star Trek universe, where the differences among species seem mostly cosmetic and cultural, we are not too far away, either. Extraterrestrials are probably culture-bearing animals with two intelligent sexes. They could be xenophobic and dangerous or at best ethnocentric, but it seems likely that they and we may share a capacity for fairness and for moralistic aggression, and to at least be able to understand one another's ethics. Physically they may be very different from us, but we should have some common ground to understand one another. Some advice for SE TI: If the extraterrestrials do contact us, have some evolutionary anthropologists and psychologists standing by.

Finally, even after all this effort, some may still be thinking, "well, if there are all those intelligent extraterrestrials out there, why haven't we ever seen them or at least received their radio transmissions?" One possible answer to this question is rather worrisome: Richard Dawkins'[56] suggestion that "intelligent life may arise quite frequently, but typically only a short time elapses between the invention of radio and technological self-destruction." Given this possibility, it behooves us to think carefully not just about the evolutionary psychology of extraterrestrials, but also about our own.

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