Primate Language and Cognition: Common Ground*

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RESEARCH of the past decade has served to underscore the close psychological relationship between humans, chimpanzees, and the other great apes. In his evolutionary theory, Darwin (1860, 1871) posited both psychological and biological continuities between animals and humans. Although the evidence for biological continuity has been strong for decades, the evidence necessary for affirmation of psychological continuity is recent.

Descartes and Animals

The absence of strong evidence for the processes of intelligence and language in animals has permitted the earlier proclamations of Descartes ([1637]1956) in the mid-1600s to spawn the belief of discontinuity. Because animals could not

talk sensibly, it was easy for people to conclude that animals had no sensibilities. They came to be viewed as "subhuman" or "infrahuman"—as not having made the grade to the exalted status of human. They were held to be without reason, thought, affect, intelligence, and language.

Humans, but not animals, were able to think because they had rational souls. Accordingly, they could be held accountable for their actions—and for their sins. When they sinned, God inflicted pain. But God would surely spare all animals from ever experiencing pain. After all, without souls, they were not responsible for their action—and, thus, could not sin. Despite the fact that the rationale for Descartes' beast-machine concept has faded with the centuries, the concept is still very much alive.

Throughout history, humans have sought lines of argument and fact that would make us unique from animals. Different we are, but not so totally different as some would think.

The Null Hypothesis, Darwin, and Continuity

Adherence to the view that our species has a totally unique psychology is to misuse the Null Hypothesis. The Null Hypothesis holds that there is "no difference" between us and animals. Only with evidence sufficient to reject that hypothesis should one argue that "a real difference" exists—one not attributable to chance. By contrast, the general tendency has been to begin with the conclusion that real differences *do* exist between the psychology of humans and animals, and that the onus is upon the researcher to come up with proof to the contrary!

Darwin basically advanced the Null Hypothesis as he argued for continuity from animals to human. He did not go so far, though, as to argue for identity of process. Apes are apes, apes are not humans; but because of the very close genetic similarity which they share (>98% shared DNA; Sarich, 1983; Andrews

and Martin, 1987; Sibley and Ahlquist, 1987), there are neurobiological grounds to anticipate some degree of similarity in their psychology.

That said, attention is now directed to behavioral research of recent years, both here and abroad, that has produced an abundance of evidence for rejection of the Cartesian beast-machine concept and for support of Darwin's postulations of continuity. Animals have been found capable of complex communication, symbolizing capacities, rule-learning, number learning, and even language.

Comparative Cognition

The Language Research Center's history rests in our long-standing interests in the parameters of human intelligence that might be traced to our nearest living relatives—the great and lesser apes, the monkeys of the New and Old Worlds, and the prosimians (Napier and Napier, 1994). One tactic for this study posited a relationship between *Transfer of Learning* and *Brain Complexity*.

Transfer of Learning

Transfer of learning is a very important element in general-ized competence. Most learning takes place in relatively specific contexts—a student studies biology at his/her desk; a teenager learns how to drive a Chevrolet; a pilot learns to fly a single-engine plane; a student learns sculpting in a studio; and so on.

Transfer of learning can influence subsequent learning (for example, acquiring information about something) and perfor-mance (for example, doing a task, taking a test, and so on) in two basic ways. First, the effect can be a facilitating or *positive* one. The learning or performing of one task might facilitate the learn-ing of a second task. Learning to drive a stick-shift Chevrolet

entails many principles that can be applied to learning to drive a variety of other cars. One "knows something quite general about driving" after the stick shift car has been mastered. The learning of one subject in biology can, and should, facilitate the learning of another, and so on. On the other hand, the effect can be an impediment or *negative* one, in part if not wholly. Thus, learning to drive in a car with a stick shift can have a negative effect on subsequently driving an automatic shift car. For example, one's left foot may flail around when one attempts to stop a car that has no clutch. Use of the feet is relevant to the stopping of most vehicles, but the specifics of what they are to do can be either positive or negative. All of us have had problems with vehicles where controls are either absent or relocated compared to the car we drive most frequently (that is, controls for turn-signals, headlights, windshield wipers, and so forth). Pilots become generally competent (*positive* transfer) in learning to fly a wide variety of planes, but past expectations about the locations of specific vital controls (that is, the throttle, the flaps control, and so on) can lead to disaster (*negative* transfer) in crisis situations where there is no time to analyze what to do to correct the problem. Finally, it is acknowledged that learning one thing, such as French, might have absolutely no transfer of learning relevance to flying a plane or driving a car.

Generally, persons who are facile at transferring even small amounts of learning have a marked advantage in new situations and are viewed as highly intelligent and clever. They are able to see common principles and logical as well as functional dimensions of relationships among diverse situations and topics. For them, for example, the learning of Latin facilitates the learning of many other languages and academic subjects. For others, Latin has no relevance to anything!

Primate Brains and Transfer of Learning

Interestingly, primate species differ both markedly and rather systematically in the ease with which they can learn *and*

transfer their learning. The size and complexity of primate brains can result in comparable amounts of learning being transferred *positively* for some species (notably the larger ones) and *negatively* for other species (notably the smaller ones). The differences in transfer are associated with average brain size per species and are not reliably associated with differences in brain size among individual specimens with a species, except insofar as brain size and complexity increases with growth and development to maturity.

Transfer of learning and skills is basic to the development of competence in both humans and animals. Accordingly, great emphasis has been placed upon the assessment of transfer-of-learning skills in studies of primate intelligence. Both conceptually and procedurally it can be studied in comparable ways across species, for we can assess the efficiency and effect of transfer relative to what the individual is known to have learned. Several of our own studies, designed to relate primate brain evolution to transfer-of-learning competence, have been facilitated by the development and use of the Transfer Index (TI) (Rumbaugh and Pate, 1984).

The TI is a procedure designed to afford equitable assessments of primates' complex learning and transfer skills. Its design attenuates artifactual differences between species' learning and performance that might be produced due to their differences of size, manual dexterity, processes of attention, and so on. Brain complexity was estimated according to Jerison's (personal communication) estimations of the "extra" brain and neurons afforded primates due to the process of encephalization. Encephalization refers to an enlargement of the brain's size/weight relative to the body's weight beyond that which would be afforded by allometric relationships that characterize a variety of proportions and weights of the body's anatomy. In other words, a certain amount of brain is needed just to service the tissue needs, processes, and basic behaviors of the body.

Thus, within limits, allometric relationships imply that large

mammals will have larger brains than small mammals. But apart from that, *encephalization* refers to the tendency for the brains, notably those of primate species and in particular those of the great apes and our own, to be extraordinarily large. It is this "extra" brain size and complexity which surely provides the basis for intelligence both in primates and humans, who also are a primate form.

Research with over 121 primate subjects of several species relates their transfer-of-learning skills, as assessed by the TI, to the dimension of brain complexity in a very interesting manner: a qualitative shift in those skills was documented in interaction with the amount of learning established prior to tests of transfer.

The amount of learning prior to test was defined by achievement standards that required the subjects to learn sets of visual discrimination learning problems to two levels of correctness—67% and 84% choices correct—to prepare them for tests of their transfer skills. These achievement standards, in effect, required that the subjects achieve specified numbers of choices correct within specified numbers of training trials prior to test for transfer of learning. As one might expect, the 84% level required that more choices be correct than did the 67% level.

The learning situation in which these performance schedules were applied was a series of two-choice, object-discrimination problems. Each problem consisted of a pair of objects that clearly differed from one another in size, color, and form. One object of each pair, if chosen, resulted in food, whereas choice of the other object resulted in no food. Once the subject achieved the level of mastery required (either 67% or 84%) for a given set of problems, the test of transfer of learning was given.

This transfer test consisted in "switching" the correctness of the objects: the object that was associated with food, if chosen, now became "incorrect," and the object which had not been associated with food now became correct. The TI computes

the degree to which transfer of learning was positive or negative—or absent—on the basis of performance on a series of problems.

Figure 1 portrays the change in test performance (percentage responses correct) obtained as the learning standard was increased from the 67% to the 84% level. And it is here that a very important finding must be clarified.

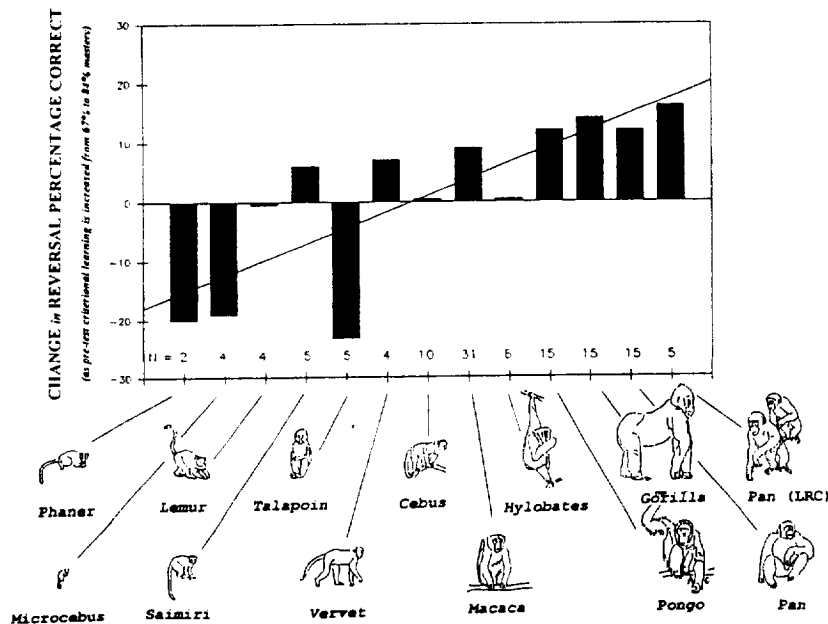As the amount of learning was increased, the prosimians and

Figure 1. The enhancement of transfer-of-learning in relation to brain complexity of primate (N = 121) is portrayed. The vertical axis quantifies the *change* in the percentage of responses that are correct as a result of the per-transfer test learning criterion being increased from 67% to 84% correct. Each point on the baseline is for a particular species, except for the one (right end) that is for 5 language-competent chimpanzees and bonobos of the Language Research Center. Their enhanced performance is believed to be due to the *enrichment* afforded by their research participation and their language skills. (See Acknowledgments for contributions of unpublished data from others. See Cooper [1980] and De Lillo & Visalberghi [1994] as sources for data on *Phaner, Microcebus, & Capuchin.* Other unpublished capuchin data was contributed by Hopkins and Suomi.)

smaller monkeys generally tended to do worse (for example, they had fewer choices correct on transfer tests after being trained to the 84% than to the 67% level). For them, increasing the amount learned handicapped their performance on transfer tests and produced *negative* transfer effects with these procedures. By contrast, the great apes and even the larger and more complex-brained monkeys improved in their transfer tests as the level of per-test learning was increased. For them, the more they knew, the better they did on transfer tests—the greater their *positive* transfer of learning.

I again emphasize that the ability to learn and to transfer one's learning to a leveraged advantage is generally held among humans to be evidence of "smartness," not "dumbness." Thus, it is here argued that the great apes are substantially smarter than monkeys and prosimians because of their ability to transfer what they have learned to a leveraged advantage in transfer tests. That advantage is so great that many of the ape and larger species of monkey subjects (that is, Rhesus macaques) do substantially better on the transfer test trials than they had been allowed to during the learning trials (for example, when trained to, say, the 67% level, they would be 78% correct on transfer tests—a value higher than required prior to test).

For primates, a large body means a disproportionately large brain and extra neurons, which, in turn, correlate highly with the values obtained from the y-axis of the figure shown (*extra* brain volume, $r = .82$; and *extra* neurons, $r = .79$, respectively). Average body weights and brain weights per species correlated highly with each other (0.96); body weight correlated highly with transfer-of-learning proficiency (0.88); and brain weight per species also correlated highly with transfer skills (0.84).

Jerison's (1991) Encephalization Coefficient, which relates brain weight to body weight, is only generally correlated with the body weights of the primate species here used. For example, although both the diminutive squirrel monkey and talapoin have higher Encephalization Coefficients than does

the massive gorilla, they are substantially below the gorilla in their complex learning and transfer skills. Consequently, that measure did not correlate significantly with transfer-of-training skills significantly.

Simian Intelligence

Before addressing the research which has perhaps most firmly cemented the continuum that relates the psychology of apes and humans—that is, *language*—let us consider the smartness of monkeys. Monkeys have an order of smartness or intelligence that is substantially below that of the apes, but even so at least the larger-sized ones are impressive.

Research at our Center defined their ability to use a joystick in a battery of complex tasks designed to measure their learning, memory, vigilance, eye-hand coordination, planning, relative-value judgments, and so on in relation to physiological changes (Rumbaugh, Richardson, Washburn, Savage-Rumbaugh, and Hopkins, 1989; Washburn, Hopkins, and Rumbaugh, 1989; Washburn and Rumbaugh, 1992a,b). For our purposes, our review of findings is limited to the following:

- Rhesus' performance on the TI and the number of trials which they work each day are the best predictors of training success on our comprehensive battery of tasks referenced above.
- Rhesus prefer to work on tasks of their choice rather than passively to receive incentives for "free."
- Rhesus respond more quickly and accurately when they can choose tasks on which to work than when those same tasks are assigned by experimental procedures.
- Rhesus are "super-learners" in that they readily learned the relative values of the numeral set 0–9 and induced their comprehensive relationships of relative values. They did this in a learning situation in which they did not have to choose the larger number in order to get pellets and then were tested on a series of novel pairs. Even on these novel test trials, they
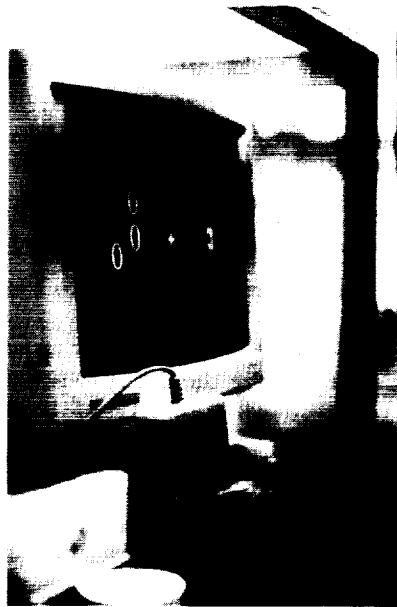
Figure 2a. and 2b. A rhesus monkey (*Macaca mulatta*) works on a numeric task portrayed on the monitor of the Language Research Center's Computerized Test System (LRC-CTS).

reliably picked the number of greater pellet value (Washburn and Rumbaugh, 1991).

- Handedness (for example, reliable use of either the right or left hand rather than both) for joystick manipulation is strongly established in Rhesus, and right-handed monkeys (for example, those who like most humans in writing do best if they use their right hand) tend to be more facile learners than left-handed monkeys.
- Rhesus monkeys manifest characteristics of selective attention similar to those of humans. For instance, they are sensitive to the Stroop-like interference when quantities, between which they are to differentiate, are comprised of Arabic numbers (Washburn, 1994). (The Stroop effect is exemplified when, for example, a human subject is asked to name the *color* of the ink in which various words are printed where the words themselves are *names* of colors—but where there is a lack of congruence between the word and the color in which it is printed. Thus, it is generally difficult to say "green" when it refers to the color of ink used to print the word "red.") When required to choose the array with the *greater* quantity of items, Rhesus monkeys do less well if that array is made up of numerals that stand for relatively small quantities (that is, 2s or 3s) compared to the other array that is made of numerals that are relatively higher (that is, 7s or 8s).

Apes and Language

But what of the apes' language abilities? It was just a few years ago that evidence then available in support of apes' capacity for language was contested by others as attributable to inadvertent cuing by the apes' mentors.[1] Even then, however, we knew that two of our chimpanzee subjects, Sherman and Austin, could look at their word-lexigrams, each being the name of either a specific food they ate or of a specific tool they used to extricate food from puzzle boxes, and categorize them accurately through use of two other word-lexigrams—one standing for "food" and the other for "tool." Their competence in doing thus, in controlled tests, documented their basic capacity for semantics—the meanings of symbols or words (Savage-Rumbaugh, 1986).

But recently our Center has produced findings that even we would not have thought possible 10 years ago. The basic finding (Savage-Rumbaugh, Murphy, Sevcik, Brakke, Williams, and Rumbaugh, 1993) is that the apes can come to understand even the syntax of human speech, at a level that compares favorably with that of a 2–1/2 year old child—if they are reared from shortly after birth in a language-structured environment. By "language-structured" environment I mean one in which the apes' caretakers talk to the infant apes as though they understand all that was being said—announcements of what is about to happen and descriptions of items selected jointly for attention by the ape and its caretaker.

Speech Comprehension by Apes

Reared in this manner, the infant ape's brain develops in a manner that enables it to acquire language—first through its comprehension and then through its expression, a pattern that characterizes the course of language acquisition in the normal child. The ape's comprehension of spoken words is assessed by whether or not it is able to select the appropriate referent for single words that it hears in controlled experimental situations. Their comprehension of syntax is assessed by their capacity to respond logically to novel sentences of request that they hear.

The research program included a child. Alia, 2–1/2 years old. The first ape was Kanzi, a bonobo—a rare species of chimpanzee (Pan paniscus).

Kanzi's comprehension of over 600 novel sentences of request was very comparable to Alia's; both complied with the requests without assistance on approximately 70% of the sentences. If explanation, comment, or encouragement were offered to the subjects when they appeared hesitant about what was being asked of them, their assessed level of correctness was down-graded. (All requests were unrehearsed.

Figure 3. Kanzi listens to words that he hears through headphones during controlled tests of his speech comprehension.

Personnel in the test room listened to loud music so that they could not hear the requests posed to Kanzi.)

How did Kanzi acquire his comprehension of language (Savage-Rumbaugh and Lewin, 1994)? Not through formal instruction, but rather just by being present while his mother, Matata, was receiving her language instruction—instruction with lexigrams, not speech comprehension. Quite possibly it was because Matata was reared by feral bonobos until about age 6-years that she never benefited reliably from her language instruction. It was as though her cognitive structure had been fully committed to topics associated with life in the forest. Though smart by every measure when out in the 55 acres of forest that surround the Language Research Center, she did not learn readily about language. By contrast, the language-learning abilities of her offspring have been impressive.

The discovery afforded by Kanzi has been corroborated with two other bonobos, Mulika (Sevcik, 1989) and Panbanisha, and

to a more limited though significant degree with a common chimpanzee, Panzee (Savage-Rumbaugh, Brakke, and Hutchins, 1992). Panbanisha and Panzee were co-reared for their first four years.

Early Environment, Rearing, and Competence

As exciting as it has been to document the apes' language skills, even more important is the principle derived from their research: it is in the logic-structure of the infants' environments that their complex abilities, competencies, and dimensions of intelligence and expression are formed. Their formation is behaviorally "silent" in that their expression might not occur until the age of 2 years or older (Savage-Rumbaugh, 1991). It is during infancy that important basic vectors of competence are formed (Rumbaugh, Hopkins, Washburn, and Savage-Rumbaugh, 1991).

Earlier studies of the 1960s and '70s made clear that chimpanzees subjected to impoverished rearing even during the first two years of infancy only are both socially and cognitively deficient in their capacity for complex learning and the transfer of learning some 12 years later as young adults (Davenport, Rogers, and Rumbaugh, 1973).

It is significant that appropriate language-structured rearing established in the ape what none of the earlier efforts designed to teach apes specific language skills through use of tutorials could—namely, the ability to comprehend speech and its syntax (Savage-Rumbaugh and Lewin, 1994). Such rearing also serves to support the spontaneous appearance (for example, without specific training) of productive language skills that approximate those of a 1–1/2 year old normal child (Greenfield and Savage-Rumbaugh, 1991, 1993).

And given the opportunity to observe a professional flint-knapper, Kanzi learned about stone tools—their use, value, and means of production (Toth, Schick, Savage-

Rumbaugh, Sevcik, and Rumbaugh, 1993). Over time, he has become a reasonably skilled flint knapper; that is, he makes stone tools and does so with good sense. He assesses his flint chips for sharpness and, quite appropriately, makes larger chips to cut thick cables of rope and smaller chips to cut fine ones.

Apes, Language, and the Human Perspective

Elsewhere (Rumbaugh and Savage-Rumbaugh, 1994) we have presented a perspective of apes and their language skills and how both the research and the controversy surrounding it has taken form across the course of the past several decades. Suffice it to say, first, that the history of behavioral science has documented that it is *very* unlikely that theorists will abandon positions for which they have become known. Major changes in perspectives frequently must await the "second" generation of scientists to incorporate the data and the best of diverse perspectives into their science. Nevertheless, the following are held to be factual and without logical refutation: (1) Apes are capable of learning the meanings and representational use of arbitrary symbols that for them have all the functional properties of words. The symbols stand for things that are not necessarily present in time and space, for activities, for the properties of things (that is, temperatures of drinks, ambient noise levels), for the individual's state (that is, hunger, thirst, sleepiness), for other animates (either ape or human or canine), for places to which they would go, for making comments on activities and recent happenings in the laboratory, and so on. These assertions are based on data obtained from controlled scientific tests, replications of studies with different subjects, as well as affirmed by social communication between humans and apes across decades. The processes whereby symbols, signs, and gestures optimally acquire these *semantic* properties are cultivated during early rearing of the

ape—just as is the case for the normal child. Formal, discrete trial training of language skills is relatively ineffective and does not establish the ability to comprehend substantial amounts of human speech. (2) Early rearing can establish in the ape the ability to understand the meanings of human speech—even novel sentences of request. Thus, the apes spontaneously acquire a capacity that is normal for the human child—though not for the ape. (3) Early rearing can establish, first, the ability to understand, to comprehend language, and, second, the ability to employ grammar as does the 1– 1-1/2 year-old child.

Critics who emphasize that the apes cannot do "all" that the normal child does and who emphasize speech production as the *sine qua non* of language err in discounting the significance of highly important findings produced by language research with apes. Research with apes has made it very clear that the basis for language is *comprehension*, not speech. Although speech is a highly efficient, unsurpassed medium for linguistic communication, competence in speech rests primarily in comprehension—and only secondarily in the speech and hearing systems that normal humans enjoy. The bedrock of human language processes are traceable to the great apes. And while the great apes are not our ancestors, they are closer to our evolutionary roots than other primate forms.

Apes are not humans—and they probably are quite happy about that fact! Notwithstanding, they are so closely related to us that it is totally reasonable that they have several of the basic elements of human intelligence and language—and indeed they do, though nothing would declare that they must! Common genetics implies not only common ancestry and morphology, it also implies common neuroscientific bases for psychology and behavior. Those who insist on the "total separation" of human and ape psychology, behavior, and competence err in discounting the evolutionary bases which supported the emergence of the primates and notably the great apes and even ourselves!

In sum, the long-held views advanced by some authorities

regarding language as a process unique to humans and the insistence by others that a barrier be "declared," regardless of data, between the basic intellectual processes of animals and humans (as for the ability to plan, reason, symbolize, and so on) have been contrary to the end that relevant research data be given their proper consideration. Research data clearly indicate that nonhuman primates, and notably the great apes, are competent in several, though not all, of the essential dimensions of language and other complex processes.

As stated above, apes are not humans, and humans are not apes. Differences between them are inherent in their genetics. Nevertheless, by the same perspective, they and we are not totally different. Thus, non-trivial similarities between the great apes and us should be expected and happily incorporated into our understanding of life, the natural world, and our "nature."

A New Comparative Perspective

In closing, Descartes and his beast-machine model of animals was wrong. That is now clear. Descartes' beast-machine model of animals has been discredited. His error should no longer be promulgated by the thinking and values of our society.

Apes have vaulted the language barrier. The psychological continuum of humans with them is in place. Apes are not humans—but despite Descartes' proclamation to the contrary, within their own existences they surely reason. Such must be the case because it is certain that their impressive learning and language skills did not evolve for the purposes attendant to those of the research laboratory.

Being competent for reasoning, they, along with us, surely can experience a number of dimensions of *being*. They are surely capable of experiencing pain. (Here it is appropriate to credit veterinary science of recent years with caring for animals that manifest symptoms of pain as probably experiencing pain.)

Apes are great, both in size and intelligence. Their care and conservation are challenges that must be met with renewed

energy and commitment. Their appropriate scientific study, conducted sensitively and responsibly, can be of great value to us as we strive to learn more accurately about the nature of our own species and how, through the management of early rearing and early experiences, we can rear generations who will be responsible to themselves, toward others, toward this planet, and toward the natural resources and wildlife that share the planet with us.

Notes

[1] See Rumbaugh and Savage-Rumbaugh, 1994, for a review.

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