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# **The Cognitive Animal**

## **Empirical and Theoretical Perspectives on Animal Cognition**

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# 31 Cognitive and Communicative Abilities of Grey Parrots

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How do we measure avian “intelligence” and communicative capacities? Two decades of study on Grey parrots (*Psittacus erithacus*) provide more questions than answers. What *is* intelligence? Can we evaluate nonhumans using human tasks and definitions? Or fairly test nonhuman sensory systems? How do nonmammalian brains process information? Do avian and mammalian cognitive capacities overlap significantly? Preliminary answers exist for the first four questions and considerable data are related to the fifth. To summarize current knowledge, here I examine concepts of intelligence, review techniques for evaluating parrot cognition, and discuss these results and implications.

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## How Can We Study Avian Intelligence?

“Intelligence” has as many definitions as researchers in the field (Kamil 1988; Sternberg and Kaufman 1998) because it is not a unitary entity, but rather many abilities that interact with stored information to “produce behaviour we see as ‘intelligent’” (Byrne 1995, p. 38). For me, intelligence involves not only using experience to solve current problems, but also knowing how to choose, from many sets of information acquired in many domains, the appropriate set for solving the current problem (Pepperberg 1990). Organisms limited to the first ability have learned important associations, but cannot transfer and adapt information—Rozin’s (1976) definition of intelligence.

But how should one study “intelligence”? My choices of subject and technique exploited Griffin’s (1976) suggestion to use communication as the primary tool. When I began my work, however, both choices were nontraditional.

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## Studying Avian Cognition

Prior to the mid-1970s, researchers studied mostly pigeons in Skinner boxes; these birds demonstrated capacities far inferior to those of mammals (Premack 1978). Such results were thought to represent the abilities of all birds, despite evidence suggesting that some avian species might exhibit more impressive cognitive and communicative feats (Koehler 1953). For example, given how parrots’ large brains, long lives, and highly social natures resemble those of primates and cetaceans, shouldn’t parrots also have evolved complex cognitive capacities? Might proper training enable them to demonstrate language-like abilities comparable to those of nonhuman primates and cetaceans?

Specifically, parrots’ vocal plasticity would make them candidates for evaluating intelligence via interspecies communication (Pepperberg 1981). Interspecies communication (1) directly states the precise content of the questions being asked; thus an animal need not determine the nature of the question through trial and error; (2) incorporates research showing that social animals respond more readily and often more accurately within an ecologically valid social context (Menzel and Juno 1985); and (3) allows data comparisons among species, including animals and humans. Interspecies communication is also an open, arbitrary, creative code—with an enormous variety of signals that allow researchers to examine the nature and extent of information an animal perceives. And two-way communication allows rigorous testing: Subjects can be required to choose responses from their entire repertoire rather than from a subset relevant only to a particular question’s topic. Moreover, an animal

that learns such a code may respond in novel, possibly innovative ways that demonstrate greater competence than the responses required in operant paradigms. Interspecies communication may thus more facilely demonstrate non-humans' inherent capacities or even enable them to learn more complex tasks.

Of course, nonhumans must be taught interspecies communication; here, too, techniques varied. I was among the few to emphasize socially interactive training (Pepperberg 1999). My model/rival (M/R) procedure, adapted from Todt (1975), uses social interaction to demonstrate targeted vocal behaviors: labeling, concept formation, clear pronunciation (Pepperberg 1981, 1991). In this procedure, a bird watches one human train another (the model/rival), i.e., ask questions (e.g., "What color?") about an item of interest to the bird. The trainer rewards correct responses with the item, demonstrating referential, functional use of labels, respectively, by providing a 1 to 1 correspondence between a label and an object, and demonstrating the use of the label as a means to obtain the item. The second human is a model for a bird's responses and its rival for the trainer's attention, and illustrates the adverse consequences of errors: Trainers respond to errors with scolding and temporarily remove the object. The model/rival is told "Try again" after garbled or incorrect responses, thus demonstrating corrective feedback. A bird is included in the interactions and is initially rewarded for an approximate response; the training is thus adjusted to its level. Then the model/rival and trainer reverse roles, showing how both use the communication process to request information or effect environmental change. Without this role reversal, the birds neither transfer responses beyond the human who posed the questions nor learn both parts of the interaction (Todt 1975)—behavior that is inconsistent with interactive, referential communication. Using this technique, I trained a Grey parrot, Alex, to identify objects,

materials, colors, and shapes, and used these abilities to examine his conceptual capacities. Such studies showed how well he transferred information across domains and facilitated comparisons with mammals, primates, and sometimes humans.

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### Specific Avian Abilities

#### **Categorization—Sorting the World into Definable Bins**

Birds sort items into shelter or not-shelter, food or not-food, predator or not-predator, mate or not-mate, conspecific or allospecific. But can birds respond to more than specific properties or stimuli patterns? Can they respond to classes or categories to which these properties or patterns belong (Premack 1978; Thomas 1980)? Can birds go beyond, for example, sorting green or not-green to recognizing the relationship between green pens and lettuce? Noting "greenness" is stimulus generalization; recognizing a category "color" involves formation of a categorical class (Pepperberg 1996). The former is relatively simple, whereas the latter is complex.

One approach to separating these abilities uses symbolic labels (Pepperberg 1983, 1996, 1999). Arbitrary, abstract sound patterns ("red", "4-corner"), hand, or pictorial signals representing concrete physical attributes (e.g., redness, squareness) are grouped into multiple higher-order abstract classes also labeled by arbitrary patterns (e.g., "color", "shape"). The ability to form these classes is not elementary, even for humans. To acquire the category "color" *and* color labels, for example, requires (1) distinguishing color from other categories; (2) isolating certain colors as focal and others as variants; (3) understanding that each color label is part of a class of labels linked under the category label "color"; and (4) producing each label appropriately (de Villiers and de Villiers 1978). Can a bird respond this way?

Alex does (Pepperberg 1983). He not only labels objects, hues, materials, and shapes, but, for example, also understands that “blue” is one instance of the category “color,” and that for any colored and shaped item, specific attributes (e.g., blue, 3-corner) represent different categories. If asked “What color?” or “What shape?”, he vocally classifies items having one of seven colors and five shapes with respect to either category. This task requires comprehending categorical concepts, not just sorting items into categories, and flexibility in changing the classification basis because he must categorize the same item by shape at one time and color at another. Such *reclassification* indicates abstract aptitude comparable to that found in chimpanzees (Hayes and Nissen 1956/1971).

In two more complicated tasks, Alex sees unique combinations of seven items. In the first, he is asked “What color is object X?”, “What shape is object Y?”, “What object is color A?”, or “What object is shape B?” (Pepperberg 1990). In the second, he must label the specific instance of one category of an item defined by two other categories; e.g., “What object is color A and shape B?” Other items exemplify one, not both defining categories. To succeed, he must understand all elements in the question and categorize conjunctively (Pepperberg 1992). His accuracy on both tasks matches that of marine mammals (Schusterman and Gisiner 1988).

### Same-Different

Researchers once thought comprehension of the concept of same-different required relational abilities absent in any nonprimates (Premack 1978; Mackintosh et al. 1985). Testing for recognition of same-different is more complex than testing knowledge of match-to- or oddity-from-sample. The former requires arbitrary symbols to represent same-different relationships between sets of items and the ability to denote which attribute is the same or different (Premack 1983). The latter requires only that a subject needs

fewer trials for the subject to respond to *B* and *B* as a match after it has learned to respond to *A* and *A* as a match; likewise for *C* and *D* after it has learned to respond to *A* and *B* as non-matching. Match-to- and oddity-from-sample responses might even be based on old-new or familiar-unfamiliar contrasts (Premack 1983)—the relative number of times *A* versus different *B*s are seen. A subject that understands same-different, however, knows not only that two non-identical blue items are related just as are two non-identical green objects—by color—but also that the blue items are the same in a separate way than two non-identical square items; moreover, it can transfer this process to any attribute and to differences (Premack 1978; Pepperberg 1999).

Natural avian behavior patterns of recognition of individuals, vocal dueling, and song matching (see the review in Stoddard 1996) require same-difference-based discrimination, implying that the ability is adaptive. In the laboratory, however, apparent same-different discriminations of vocalizations may be based instead on learning unique call characteristics (Park and Dooling 1985) or a differential weighing of information in various song features; the results could depend on the experimenter’s choice of features (Nelson 1988). Also, experimental design may not reveal the subjects’ same-different perception. Starlings (*Sturnus vulgaris*), for example, classify novel series of tones as the same or different from an ascending or descending reference series, but unless they are pressed, do so only for sequences within their training frequency range (Hulse et al. 1990). And none of these studies required labeling the same-different relation or indicating which attributes were the same or different, or transfer to novel situations (e.g., different species’ calls or songs; Pepperberg 1987).

Alex, however, has learned abstract concepts of same-different and has learned to respond to an absence of information about these concepts. Given two identical items or ones that vary with respect to some or all attributes of color, shape,

and material, he utters the appropriate category label for what is the same or different (Pepperberg 1987); if nothing is the same or different, he replies “none” (Pepperberg 1988). He responds accurately to novel items, colors, shapes, and materials, including those he cannot label, and to specific queries. This is not done from rote training or the objects’ physical attributes. If he were ignoring our queries—for example, “What’s same?” for a red and a blue wooden square—and responding based on prior training, he would ascertain and label the one anomalous attribute (here color). Instead, in such cases he gives one of two appropriate answers (“shape,” “mah-mah” [matter]). The test conditions match Premack’s (1983) chimpanzee study in rigor. Alex also transfers concepts of same-different and absence to untrained situations. When he was first shown two same-sized objects after learning to answer the question “What color-matter is bigger or smaller?” for any two items, he asked “What’s same?”, then said “None” (Pepperberg and Brezinsky 1991).

### Numerical Capacities

Numerical studies in animals are difficult (Pepperberg 1999). Even for humans, researchers disagree on the stages (content, ordering) of numerical ability and whether language affects numerical tasks (e.g., Davis and Pérusse 1988; Fuson 1988, 1995; Gelman and Gallistel 1986; Siegler 1991; Starkey and Cooper 1995). No avian subjects count in the sense described for humans (Fuson 1988), but they nevertheless demonstrate numerical abilities. To distinguish counting from subitizing (a simpler perceptual mechanism involving pattern recognition), I constructed collections of four groups of items varying in two color and two object categories (e.g., blue and red keys and cars), and asked Alex to quantify items defined by one color and one object category (e.g., “How many blue key?”; Pepperberg 1994). His accuracy (83.3 percent)

replicates that of humans in a comparable study by Trick and Pylyshyn (1993), who argue that humans cannot subitize when quantifying a subset of items distinguished from other subsets by a conjunction of qualifiers. Although the same behavior may be mediated by different mechanisms in different species, the data for Alex suggest that a nonhuman, nonprimate, nonmammal has abilities that in an ape would be taken to indicate human competence.

### Communication

Communication elucidates many avian capacities. Some psittacids (e.g., *Amazona vittata*, Snyder et al. 1987), corvids (crows, Maccarone 1987; Florida scrub jays, *Aphelocoma coerulescens coerulescens*, McGowan and Woolfenden 1989) and chickens (*Gallus gallus*, Evans et al. 1993) may, like vervet monkeys (*Cercopithecus aethiops*), vocally categorize different predators (Seyfarth et al. 1980). Grey parrots use English speech to label and categorize items, quantify arrays, and respond to queries concerning same-different and relative and conjunctive concepts (Pepperberg 1990, 1992, 1994; Pepperberg and Brezinsky 1991). Thus, for any two items, Alex can be asked “What’s same-different?”, “How many?”, or “What color-matter is bigger-smaller?” To respond appropriately, he must not only understand each concept, but also must determine which is targeted and from what domain an answer must originate, which fits my original definition of intelligence. His abilities suggest striking parallels between birds and primates.

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### Avian Intelligence from a Human Perspective

Despite the above data, two problems remain when evaluating nonhuman intelligence, particularly in creatures so different from humans as parrots. First, tasks used to evaluate nonhumans are interpreted with respect to human

sensory systems and perceptions of intelligence. Second, specific abilities vary across avian species.

Human biases, which underlie all evaluations of nonhumans, can be addressed by designing—with extreme care—tasks relevant to nonhuman ecology and physiology. We study songbird cognition, for example, not by how birds resolve match-to-sample problems on colored lights, but by how they categorize, repeat, discriminate, and order songs in territorial encounters (e.g., Todt and Hultsch 1996; Kroodsmma and Byers 1998). For the importance of such design, consider a tongue-in-cheek analogy: A test of how a human male's choice of song attracts mates and repels intruders would reveal significant incompetence (Pepperberg 1999).

Avian abilities also differ across species. No one species illustrates the range of avian intelligence. Birds with large vocal repertoires learn auditory discriminations faster than birds with small repertoires (Cynx 1995); caching birds outperform noncachers in spatial but not in nonspatial tasks (Olson et al. 1995). The knowledge that cachers rarely have large vocal repertoires and that versatile songsters generally do not cache precludes cross-species comparisons of similar intelligence types, intraspecies comparisons of different intelligence types, and limits research on information transfer across domains. These problems might be resolved by positing that such differences correspond to various specialized human intelligences (e.g., Gardner 1983; Kamil 1988), and, as for humans (Sternberg 1997), that the same basic, underlying processing capacities mediate different abilities. Caching and song storage involve different brain areas, but we do not know if different mechanisms encode changes representing learning and memory within these different structures. Even so, whether specialized avian abilities reflect specific or general mechanisms, data demonstrating the range of avian capacities suggest the need for further study.

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## Summary

Despite the concerns expressed here, judgments about human intelligence most likely apply to nonhumans. As an example, substitute “species” (my italics) for “culture” in the following quote from Sternberg and Kaufman:

[*Species*] designate as “intelligent” the cognitive, social, and behavioral attributes that they value as adaptive to the requirements of living. . . . To the extent that there is overlap in these attributes across [*species*], there will be overlap in the [*species*]’ conceptions of intelligence. Although conceptions of intelligence may vary across [*species*], the underlying cognitive attributes probably do not. . . . As a result there is probably a common core of cognitive skills that underlies intelligence in all [*species*], with the cognitive skills having different manifestations across the [*species*]. (Sternberg and Kaufman 1998, p. 497)

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## References

- Byrne, R. (1995). *The Thinking Ape: Evolutionary Origins of Intelligence*. Oxford: Oxford University Press.
- Cynx, J. (1995). Similarities in absolute and relative pitch perception in songbirds (starling and zebra finch) and a nonsongbird (pigeon). *Journal of Comparative Psychology* 109: 261–267.
- Davis, H. and Pérusse, R. (1988). Numerical competence in animals: Definitional issues, current evidence, and a new research agenda. *Behavioral and Brain Sciences* 11: 561–579.
- de Villiers, J. G., and de Villiers, P. A. (1978). *Language Acquisition*. Cambridge, Mass.: Harvard University Press.
- Evans, C. S., Evans, L., and Marler, P. (1993). On the meaning of alarm calls: Functional reference in an avian vocal system. *Animal Behaviour* 46: 23–38.
- Fuson, K. C. (1988). *Children's Counting and Concepts of Numbers*. New York: Springer-Verlag.
- Fuson, K. C. (1995). Aspects and uses of counting: An AUC framework for considering research on counting to update the Gelman/Gallistel counting principles. *Cahiers de Psychologie Cognitive* 14: 724–731.

- Gardner, H. (1983). *Frames of Mind: The Theory of Multiple Intelligences*. New York: Basic Books.
- Gelman, R. and Gallistel, C. R. (1986). *The Child's Understanding of Number*, 2nd ed. Cambridge, Mass.: Harvard University Press.
- Griffin, D. R. (1976). *The Question of Animal Awareness: Evolutionary Continuity of Mental Experience*. New York: Rockefeller University Press.
- Hayes, K. J. and Nissen, C. H. (1956/1971). Higher mental functions of a home-raised chimpanzee. In *Behavior of Nonhuman Primates*. Vol. 4, A. Schrier and F. Stollnitz, eds., pp. 57–115. New York: Academic Press.
- Hulse, S. H., Page, S. C., and Braaten, R. F. (1990). Frequency range size and the frequency range constraint in auditory perception by European starlings (*Sturnus vulgaris*). *Animal Learning & Behavior* 18: 238–245.
- Kamil, A. C. (1988). A synthetic approach to the study of animal intelligence. In *Comparative Perspectives in Modern Psychology. Nebraska Symposium on Motivation*. Vol. 7, D. Leger, eds., pp. 257–308. Lincoln: University of Nebraska Press.
- Koehler, O. (1953). Thinking without words. *Proceedings of the XIVth International Congress of Zoology*. pp. 75–88.
- Kroodsma, D. E. and Byers, B. E. (1998). Songbird song repertoires: An ethological approach to studying cognition. In *Animal Cognition in Nature*, R. P. Balda, I. M. Pepperberg, and A. C. Kamil, eds., pp. 305–336. London: Academic Press.
- Maccarone, A. D. (1987). Sentinel behaviour in American crows. *Bird Behaviour* 7: 93–95.
- Mackintosh, N. J., Wilson, B., and Boakes, R. A. (1985). Differences in mechanism of intelligence among vertebrates. *Philosophical Transactions of the Royal Society, London B308*: 53–65.
- McGowan, K. J. and Woolfenden, G. E. (1989). A sentinel system in the Florida scrub jay. *Animal Behaviour* 37: 1000–1006.
- Menzel, E. W., Jr., and Juno, C. (1985). Social foraging in marmoset monkeys and the question of intelligence. *Philosophical Transactions of the Royal Society, London B308*: 145–158.
- Nelson, D. A. (1988). Feature weighting in species song recognition by the field sparrow (*Spizella pusilla*). *Behaviour* 106: 158–182.
- Olson, D. J., Kamil, A. C., Balda, R. P., and Nims, P. J. (1995). Performance of four seed caching corvid species in operant tests of nonspatial and spatial memory. *Journal of Comparative Psychology* 109: 173–181.
- Park, T. J. and Dooling, R. J. (1985). Perception of species-specific contact calls by budgerigars (*Melopsittacus undulatus*). *Journal of Comparative Psychology* 99: 391–402.
- Pepperberg, I. M. (1981). Functional vocalizations by an African Grey parrot (*Psittacus erithacus*). *Zeitschrift für Tierpsychologie* 55: 139–160.
- Pepperberg, I. M. (1983). Cognition in the African Grey parrot: Preliminary evidence for auditory/vocal comprehension of the class concept. *Animal Learning & Behavior* 11: 179–185.
- Pepperberg, I. M. (1987). Acquisition of the same/different concept by an African Grey parrot (*Psittacus erithacus*): Learning with respect to color, shape, and material. *Animal Learning & Behavior* 15: 423–432.
- Pepperberg, I. M. (1988). Comprehension of “absence” by an African Grey parrot: Learning with respect to questions of same/different. *Journal of the Experimental Analysis of Behavior* 50: 553–564.
- Pepperberg, I. M. (1990). Cognition in an African Grey parrot (*Psittacus erithacus*): Further evidence for comprehension of categories and labels. *Journal of Comparative Psychology* 104: 41–52.
- Pepperberg, I. M. (1991). Learning to communicate: The effects of social interaction. In *Perspectives in Ethology*. Vol. 9, P. P. G. Bateson and P. H. Klopfer, eds., pp. 119–162. New York: Plenum.
- Pepperberg, I. M. (1992). Proficient performance of a conjunctive, recursive task by an African Grey parrot (*Psittacus erithacus*). *Journal of Comparative Psychology* 106: 295–305.
- Pepperberg, I. M. (1994). Evidence for numerical competence in a Grey parrot (*Psittacus erithacus*). *Journal of Comparative Psychology* 108: 36–44.
- Pepperberg, I. M. (1996). Categorical class formation by an African Grey parrot (*Psittacus erithacus*). In *Stimulus Class Formation in Humans and Animals*, T. R. Zentall and P. R. Smeets, eds., pp. 71–90. Amsterdam: Elsevier.
- Pepperberg, I. M. (1999). *The Alex Studies: Cognitive and Communicative Abilities of Grey Parrots*. Cambridge, Mass.: Harvard University Press.

- Pepperberg, I. M. and Brezinsky, M. V. (1991). Acquisition of a relative class concept by an African Grey parrot (*Psittacus erithacus*): Discriminations based on relative size. *Journal of Comparative Psychology* 105: 286–294.
- Premack, D. (1978). On the abstractness of human concepts: Why it would be difficult to talk to a pigeon. In *Cognitive Processes in Animal Behavior*, S. H. Hulse, H. Fowler, and W. K. Honig, eds., pp. 421–451. Hillsdale, N.J.: Lawrence Erlbaum Associates.
- Premack, D. (1983). The codes of man and beasts. *Behavioral and Brain Sciences* 6: 125–176.
- Rozin, P. (1976). The evolution of intelligence and access to the cognitive unconscious. In *Progress in Psychobiology and Physiological Psychology*. Vol. 6, J. M. Sprague and A. N. Epstein, eds., pp. 245–280. New York: Academic Press.
- Schusterman, R. J. and Gisiner, R. (1988). Artificial language comprehension in dolphins and sea lions: The essential cognitive skills. *Psychological Record* 38: 311–348.
- Seyfarth, R. M., Cheney, D. L., and Marler, P. (1980). Vervet monkey alarm calls: Semantic communication in a free-ranging primate. *Animal Behaviour* 28: 1070–1094.
- Siegler, R. S. (1991). In young children's counting, procedures precede principles. *Educational Psychology Review* 3: 127–135.
- Snyder, N. F., Wiley, J. W., and Kepler, C. B. (1987). *The Parrots of Luquillo: Natural History and Conservation of the Puerto Rican Parrot*. Los Angeles: Western Foundation for Vertebrate Zoology.
- Starkey, P. and Cooper, R. G. (1995). The development of subitizing in young children. *British Journal of Developmental Psychology* 13: 399–420.
- Sternberg, R. J. (1997). The concept of intelligence and its role in lifelong learning and success. *American Psychologist* 52: 1030–1037.
- Sternberg, R. J. and Kaufman, J. C. (1998). Human abilities. *Annual Review of Psychology* 49: 479–502.
- Stoddard, P. K. (1996). Vocal recognition of neighbors by territorial passerines. In *Ecology and Evolution of Acoustic Communication in Birds*, D. E. Kroodsma and E. H. Miller, eds., pp. 356–374. Ithaca, N.Y.: Cornell University Press.
- Thomas, R. K. (1980). Evolution of intelligence: An approach to its assessment. *Brain, Behavior, and Evolution* 17: 454–472.
- Todt, D. (1975). Social learning of vocal patterns and modes of their applications in Grey parrots. *Zeitschrift für Tierpsychologie* 39: 178–188.
- Todt, D. and Hultsch, H. (1996). Acquisition and performance of repertoires: Ways of coping with diversity and versatility. In *Ecology and Evolution of Communication in Birds*, D. E. Kroodsma and E. H. Miller, eds., pp. 79–96. Ithaca, N.Y.: Cornell University Press.
- Trick, L. and Pylyshyn, Z. (1993). What enumeration studies can show us about spatial attention: Evidence for limited capacity preattentive processing. *Journal of Experimental Psychology: Human Perception and Performance* 19: 331–351.



