Cognitive and Communicative Abilities of Grey Parrots (*Psittacus erithacus*)

Irene Maxine Pepperberg

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 significantly overlap? Preliminary answers exist for the first four questions;

considerable data relate to the fifth. To summarize current knowledge, I examine concepts of

intelligence, review techniques for evaluating parrot cognition, and discuss results and

implications.

How Can We Study Avian Intelligence?

'Intelligence' garners 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 1995:38). 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 the current

problem (Pepperberg 1990). Organisms limited to the first ability have learned important

associations but cannot transfer and adapt information -- Rozin's (1976) hallmark of intelligence.

But how to 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.

Studying Avian Cognition

Prior to mid-1970, 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). Given how parrots' large-brains, long-lives, and highly social nature 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 (a) directly states the precise content of questions being asked; thus an animal needn't determine the nature of the question through trial-and-error; (b) incorporates research showing that social animals respond more readily and often more accurately within an ecologically valid social context (Menzel and Juno 1985); and (c) 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 query's topic. Moreover, an animal that learns such a code may

respond in novel, possibly innovative ways that demonstrate greater competence than required

responses of operant paradigms. Interspecies communication may thus more facilely

demonstrate nonhumans' inherent capacities or even enable learning of 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). 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 1:1

correspondence between label and object, and modeling label use 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 aversive 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 interactions and initially

rewarded for an approximate response; training is thus adjusted to its level. Model/rival and trainer

reverse roles, showing how both use the communicative process to request information or effect

environmental change. Without role reversal, birds neither transfer responses beyond the human

who posed questions nor learn both parts of the interaction (Todt 1975) -- behavior inconsistent

with interactive, referential communication. With 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.

Specific Avian Abilities

Categorization -- sorting the world into definable bins. Birds sort items into shelter/not-shelter, food/not-food, predator/not-predator, mate/not-mate, conspecific/allospecific. But can birds respond to more than specific properties or stimuli patterns: to classes or categories to which these properties or patterns belong (Premack 1978; Thomas 1980)? Can birds go beyond, for example, sorting green/not green to recognizing the *relationship* between green pens and lettuce? Noting "greenness" is stimulus generalization; recognizing a category "color" is categorical class formation (Pepperberg 1996). The former is relatively simple; the latter 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 (a) distinguishing color from other categories; (b) isolating certain colors as focal and others as variants; (c) understanding that each color label is part of a class of labels linked under the category label "color"; and (d) 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 queried "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 *re*classification indicates "abstract aptitude" comparable to chimpanzees (Hayes and Nissen 1956/1971).

In two more complicated tasks, Alex sees unique combinations of 7 items. In the first, he is queried "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 query 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 same/different required relational abilities absent in any nonprimates (Premack 1978; Mackintosh et al. 1985). Same/ different is more complex than 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 same/different (Premack 1983). The latter require only that a subject need fewer trials to respond to B and B as a match after learning to respond to A and A as a match; likewise for C and D after learning to respond to A and B as nonmatching. 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 Bs are seen. A

subject that understands same/different, however, knows not only that two nonidentical blue items are related just as are two nonidentical green objects -- by color -- but also that the blue items are "same" in a separate way than two nonidentical square items, and, moreover, can transfer to *any* attribute and to difference (Premack 1978; Pepperberg 1999).

Natural avian behavior patterns of individual recognition, vocal dueling and song matching (review in Stoddard 1996) require same/difference-based discrimination, implying 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; results could depend on experimenters' choice of features (Nelson 1988). Too, experimental design may not reveal subjects' same/different perception. Starlings (*Sturnus vulgarus*), for example, classify novel series of tones as same/different from ascending or descending reference series but, unless pressed, only for sequences within their training frequency range (Hulse el al. 1990). And none of these studies required *labeling* the same/different relation or which *attributes* were same or different, or transfer to novel situations (different species' calls or songs; Pepperberg 1987).

Alex, however, learned abstract concepts of same/different and to respond to 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 same or different (Pepperberg 1987); if nothing is 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, not from rote training or 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]). Test conditions match Premack's (1983) chimpanzee study in rigor. Alex also transfers concepts of same/different and absence to untrained situations: When first shown two same-sized objects after learning to answer "What color/matter is bigger/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 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%) 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, Alex's data 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 determine which is targeted and from what domain an answer must originate, apropos my original definition of intelligence. His abilities suggest striking parallels between birds and primates.

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; Kroodsma and Byers 1998). For the importance of such design, consider a tongue-in-cheek analogy: Testing how a human male's song choice 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 nonspatial tasks (Olson et al. 1995). Knowing that cachers rarely have large vocal repertoires and 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.

Summary

Despite the above concerns, judgments about human intelligence likely apply to nonhumans; substitute 'species' (my italics) for 'culture' in a quote from Sternberg and Kaufman (1998:497): "*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*."

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