Applying a creativity framework to animal cognition

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Abstract

In the field of creativity, psychologists typically only study humans and biologists or ethologists usually focus either on animal problem solving or consider creativity to be an evolutionary adaptation. Yet a fuller application of creativity principles to animal behavior may both shed insight into animal cognition and expand current notions of creativity. We propose a framework for animal creativity based both on animal behavior research and creativity theories. The framework proposes different creative capabilities required for each level—i.e., one does not have to complete level 2 to reach level 3, however one does have to possess higher creative abilities. The first level is the simple ability to recognize novelty. Next is observational learning, which raises questions about imitation, intention of behavior, and the cultural transmission of creative behaviors. At the peak is creating a tool or a behavior with the specific understanding that is new and different.

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1. Introduction

Ever since Guilford’s (1950) call to arms for more research on creativity, there have been dozens of outstanding theories of creativity proposed. Some theories focus
on the creative person—such as Amabile’s (1982, 1996) Componential model, in which an individual’s motivation for the task at hand intersects with both domain-relevant skills (such as knowledge) and creativity-relevant skills (such as being able to generate novel ideas). Theories can also focus on the creative product—such as Sternberg, Kaufman, and Pretz’s (2002) Propulsion theory, which proposes eight different types of creative contributions that can advance a field. Other theories focus on the creative process, such as Csikszentmihalyi’s (1990) theory of “Flow,” a state of intense engagement that often is associated with creative performance.

Yet although these many theories are expansive and cover most imaginable facets of creativity, they focus solely on humans. This focus is not surprising, as most creativity researchers are psychologists, not biologists, and in strictly biological terms, creativity is very hard to describe (Greenberg, 2003). Biologists or ethologists who have studied creativity have often focused on animal insight or problem solving—narrow aspects of creativity theory—or examined innovative behavior as an evolutionary adaptation in an individual species. Yet a fuller application of some psychological creativity theories and principles to animal behavior may serve two purposes: it may shed additional insight into animal cognition, and it may expand current notions of creativity.

In this paper, we propose a framework for animal creativity based both on animal behavior research and creativity theories. We hope that this framework will prove helpful in future studies of advanced animal cognition (Fig. 1).

2. Basic definitions

Most definitions of creativity include two components. First, in order for something to be considered creative, it must represent something different, new, or innovative (Baer, 1997). In addition, a creative response is useful and relevant. A
certain level of high quality is often linked with appropriateness—not only to fulfill task demands, but also to do it well (Sternberg, 1999; Sternberg, Kaufman, & Pretz, 2002). Another way of expressing the innovative-appropriate distinction is found in the Geneplore model (Finke, Ward, & Smith, 1992). The Geneplore has two phases—generative and exploratory. Generation refers to generating many different ideas, while exploration refers to evaluating these possible options and choosing the best one (or ones).

This definition can be applied to animal behavior, particularly environmental enrichment for animals in zoos or aquariums. Environmental enrichment for captive animals refers to the practice of stimulating natural and/or cognitive behavior by providing activities to the animal (Shepherdson, 1998). It has been positively correlated with the psychological well-being of captive animals, as well as other factors such as physical health and reproductive rates (Kreiger, Hutchins, & Fascione, 1998). This practice is becoming extremely prominent in zoos and aquariums, and increasing portions of annual budgets are being devoted to enrichment programs (Shepherdson, 1998). When an animal is presented, for example, with a new toy filled with food, she or he tries to obtain the food, often using new or different techniques in a task-appropriate way. However, the enrichment item may also be used for purposes other than what it is intended—such as aggression toward fellow animals or trainers. In this situation, the animal may be engaging in innovative behavior, but not appropriate behavior.

The idea of appropriateness to task, although a common concept in the creativity literature, may require a leap of logic for animals: the assumption that the animal is aware that the final purpose of the toy is to obtain food, and not to be used for aggression or another behavior. This conclusion may not be unanimously accepted, but we are assuming for the purpose of this paper that animals accustomed to enrichment devices that contain food are aware of the intended purpose.

3. Guilford and Torrance’s distinctions

Another approach to creativity can be found in Guilford’s (1950, 1967, 1988) work, which served as the foundation for the Torrance Tests of Creative Thinking (TTCT; Torrance, 1974), probably the most popular creativity measure. Guilford and Torrance’s work proposes four types of measured creativity: fluency, flexibility, originality, and elaboration. Fluency represents quantity, or the number of ideas generated. Flexibility is being able to produce many different types of ideas—rather than counting the number of ideas, flexibility looks at how many categories these ideas fit into. Originality is being able to produce the most unusual ideas. Finally, elaboration is the ability to develop ideas and give supportive details and examples.

Although there are no Torrance Tests for animals, there is a popular training technique that produces some measure of three of the four scores. As described by Pryor (1999), 101 Things to do with a Box was initially developed as a marine mammal training game, but morphed into a popular training technique for a wide
variety of animals (and eventually named by dog trainers who used a box prop). In the late 1960s, working with Rough Toothed Porpoises (*Steno bredanensis*), Pryor conditioned the animals to provide a novel response on cue. To accomplish this task, Pryor began a training session without giving any cues. As a result, the porpoises would swim around and eventually begin offering behaviors out of frustration. When a new behavior (one never seen by Pryor), “A,” was presented, it was reinforced. The session continued, but the next time behavior “A” was offered, it was not reinforced. Pryor waited until a new behavior, “B,” was presented, again out of frustration, and reinforced this new behavior. This “game” could (and did) continue until Pryor and her trainers elicited behaviors from the *Stenos* as elaborate as multiple back flips (Pryor, Haag, & O’Reilly, 1969; Pryor, 1994). Later versions of the game utilized a prop for these innovative sessions in order to expand the amount of potential behaviors.

In its most recent incarnation, the criteria for *101 Things to do with a Box* tends to vary across animal trainers and facilities—animals may be asked to perform a behavior merely different from the last one, a behavior not performed in the particular session, or a completely novel behavior. Additionally, criteria for differentiating behaviors may differ—is a seal slapping one flipper on the surface of the water while holding a toy with the other flipper the same behavior as the flipper slap with no toy?

Innovative sessions tend to last for more than one behavior, which allows a trainer to look at fluency—how many different ideas can an animal produce? Animals participating in innovative sessions produce multiple types of behaviors (some may be vocalizations, some may involve props, some may be body movements, etc.). A trainer can therefore look at flexibility—how many categories of behaviors are present? Finally, innovative sessions can be used to examine originality—how unique or rare a specific behavior is compared to all of the other behaviors the trainer has observed.

Only the fourth type, elaboration, poses a special problem for trainers, because unwanted side effects may develop as a result of attempting to get an animal to elaborate on a behavior. Indeed, the question of elaboration highlights the distinction between theory-driven creativity research and practice-driven training sessions. A dolphin, in an innovative session, may offer a spectacular behavior that the trainer wishes to capture and reinforce for future sessions. If the animal is asked to repeat or elaborate this behavior, then the object of the training session has just changed. Such a change is almost impossible to adequately convey to the animal. As a result, any genuine attempt to measure an animal’s ability to elaborate would likely end the innovative session and cause uncertainty as to whether the results of the measurement were confounded by misunderstanding of the task.

4. Past integrations

There have been some attempts to look at creativity in animals. Early ideas focused on insight. Kohler (1927) studied primates’ problem-solving abilities, and
found that the first thing that a primate would do when faced with a challenging situation was to try every possible solution within their standard repertoire of behaviors. Kohler observed that the primate would then sit and do nothing, only to then rise and perform a novel chain of behaviors to solve the problem. The primate behavior was similar to the “aha!” theory of insight in problem solving, in which a correct solution suddenly emerges after initial difficulty (Kaplan & Simon, 1990).

Since Kohler’s initial work, one study showed that in order for this chain of behaviors to occur, all of the behaviors must already be a part of the subject’s repertoire, or the sequence will break down (Epstein, Lanza, & Skinner, 1981). It is likely, therefore, that such an insight is not as much a demonstration of novel behavior as Kohler believed. In an interesting corollary, Laule and Desmond (1992) observed that dolphins would perform novel behaviors of their own initiative during non-session time, but only after a basic form of the behavior had been trained, again showing novel use of a familiar behavior as Epstein et al. (1981) observed.

Other research studies that have included animal creativity have done so within the framework of evolutionary adaptation. Sol (2003) provides an excellent table summarizing eight specific and distinct hypotheses concerning the impact of innovation on ecology and evolution. At the most basic of evolutionary levels, the species best able to make a living is the one most likely to survive. In a world that is constantly changing, this may also necessitate being the species that can adapt to a changing situation easiest (Darwin, 1872). A simplified example might be that of an animal that is highly specialized and can only obtain its food via hiding behind a bush and seizing its prey, and would therefore be doomed when the bushes burn down—unless it learns to hide behind a rock. Species unable to keep up with changes in their environment are far less likely to survive. Studies have shown that invasive species are more successful if they can adapt to their new environments better and more rapidly, and that the frequency of novel foraging events in home territory was one factor that predicted success in 69 different species of birds when invading new areas (Sol, Timmermans, & Lefebvre, 2002). Novel foraging in the wild has been witnessed in multiple reports of birds of different species drowning prey in puddles or other bodies of water (Fitzpatrick, 1979; Grieg, 1979). Such innovate behavior may also be useful in defending ones home; feigning injury to lure a predator away from the nest is a common strategy in plovers (Charadrius spp.). Even if feigning injury can be considered to be an innate behavior, plovers have been observed to adapt their displays according to the predator they are trying to distract (Griffin, 1992).

Behavior that may be considered creative can also play a part in sexual selection for some animals. Australian bowerbirds are well known for the elaborate nests the males create to lure females to mate with them. The more elaborate and brightly colored the nest, the more successful the male is at mating with females (Borgia, 1985). In further studies, these birds actually show a preference for uniqueness; they selectively decorate with flowers that are uncommon in the immediate area (Borgia,
Kaatz, & Condit, 1987). These nests differ in shape, size, and construction over species of bowerbird, in addition to variation among individuals of the same species (Griffin, 1992).

Currently, one measure of innovation in animals is in use. Developed by Lefebvre, Whittle, Lascaris, and Finkelstein (1997), it involves reviewing the literature for the species in question, counting the reported incidences of innovation, and calculating an innovation rate, as reported. Sol (2003) mentions that several questions have been raised about this technique, accusing it of being biased by the amount of study devoted to a particular species, and by the number of times researchers do or do not report an innovation or the number of times that the reported innovation does or does not get published (Sol, 2003). However, it is being reported that these factors can be adequately controlled for or that they have little or no effect on the data (Sol, 2003).

5. A three-step pyramid of animal creativity

Beyond the research present, there has been no scientific theory on the nature of animal creativity (Greenberg, 2003). We propose a three-step pyramid for categorizing a wide range of behaviors. At the most common and least challenging level is the simple ability to recognize novelty—a basic prerequisite for being creative. At the second level is observational learning, which raises questions about imitation, intention of behavior, and the cultural transmission of creative behaviors. Finally, at the peak is the actual ability to be innovative—to create a tool or a behavior that is new and different with the specific understanding that it is new and different. We would argue that the pyramid is not a hierarchy, per se, in that an animal does not have to first master observational learning in order to show innovation. Instead, we see the pyramid more as a framework for creative capabilities, of which more would be required for innovation than observational learning.

The relationship between creativity and intellectual abilities has been well studied in humans. Barron and Harrington (1981), in a review of the creativity and intelligence literature, found numerous (if often weak) correlations between measures of intelligence and creative achievement. While intelligence is a necessary (but not sufficient) condition for creativity, the relationship between intelligence and creativity is only true up to approximately an IQ of 120; once an IQ reaches 120, the chances are small that any further advances in IQ will correspond with higher levels of creativity (Getzels & Jackson, 1962; Guilford, 1964, 1968; Harris, 2004; MacKinnon, 1962). However, for most people (if not people with the highest IQs), higher intelligence is related to higher creativity. One study that may indicate that a similar relationship may exist in animals is Reader and MacDonald (2003), who found clear correlations between innovation rate (using the measure developed by Lefebvre et al., 1997) and measures of intelligence and learning.
5.1. Recognition of novelty

On a very basic level, the first step toward creativity is the ability to recognize something new. This ability can be found in a wide variety of animals. Much of the research in this area has focused on neophobia, or the fear of new things. For example, a year-long period of novel enrichment caused Orange Winged Amazon Parrots to show less fear of novel objects and of new human handlers. Birds were more likely to want to interact with familiar human handlers if they were not exposed to novelty (Meehan & Mench, 2002). Other studies found a decrease in fear in domestic chicks due to exposure to novelty (Jones and Waddingon, 1992), and that pigs housed without enrichment were more likely to interact socially with a familiar handler (Schouaten, 1986).

Desensitization to novel objects has also been shown in many animals. For animal trainers and handlers, desensitization is a mainstay of training programs. Desensitization can be applied to a wide range of animals, such as electric fish, which show an electrical discharge increase upon interaction with a novel object (Lissman, 1958). Even this electrical discharge can be habituated (Laming & Ennis, 1982). Desensitization techniques can help animals in captivity to acclimate to new people, situations, and sounds—as well as veterinary procedures and equipment (Laule & Desmond, 1998). Such techniques allow many husbandry and veterinary care procedures to run smoothly and without restraint (Kuczaj, Lacinak, & Turner, 1998). However, desensitization also means that animals need constant variation of their environment in order to stimulate interest, creativity, and intellect.

Other research on animal recognition of novelty has focused on memory and cognitive abilities. For example, research with sea lions has shown that their short-term memory is easily disrupted by new information (Schusterman, Hanggi, & Gisiner, 1993). Whether the sea lions (or any other animal) can remember that an item is new has yet to be researched. If animals did not remember their own recognition of novelty, then a zoo or aquarium could theoretically save money on their enrichment expenses. If an animal finds a new toy exciting and different on both day one and day five, then new toys would not need to be purchased as often.

5.2. Observational learning

The next step in the pyramid framework is observational learning. One of the most well known examples of this step can be found in the Japanese macaques (Macaca fuscata), which traditionally dip potatoes and other food into water to wash them off. This behavior was first observed to originate with one female, and it gradually spread to the entire population. It is now taught to every infant (Kawai, 1965). In captivity, we see this when an animal learns to perform behaviors simply by watching a compatriot (Pryor, 1994). In fact, imitation is so reliable a mechanism (Bandura, 1977) it is sometimes used as a training technique. Work with Killer Whales (Orcinus orca) has shown this to be particularly effective within the first year of age (Turner...
et al., 1992), and that imitation can even take place if time has past since the behavior was witnessed (Kuczaj, 1987). In this way—depending on the point of reference you take—the process of observational learning can act both as a mechanism for spreading innovative behavior (as in the macaques), or as a mechanism to maintain a traditional behavior (such as the maintenance of a trained behavior in a population) (Galef Jr., 2003). We will use the point of reference of the former. In either situation, however, observational learning requires an audience; a learner or group of learners who somehow have deemed a behavior important enough to devote their time and energy to learning it (Hauser, 2003).

However, different types of observational learning can be difficult to distinguish. How can the learning of a novel behavior be discriminated from mere imitation? There is even some debate as to the ability of an animal to imitate at all—some maintain that animals are not capable of true, conscious, imitation (Miklosi, 1999). These researchers define imitation as requiring both the ability to understand the actions of the animal being copied, and the understanding that imitating the behavior is the way to achieve the same ends (Call & Tomasello, 1995; Whiten & Ham, 1992). In addition, there is difference between imitation and emulation, in which imitation in observational learning is defined as making a direct copy, whereas emulation is defined as reaching the same ends by different means (Whiten, Custance, Gomez, Teixidor, & Bard, 1996), a concept which would require much more “creative” thinking on the part of the animal.

When studying observational learning or using it for enrichment purposes in an environment with multiple animals, failure to display a behavior that was supposed to be learned via observational learning does not necessarily mean the behavior was not learned. The animal may be unable to perform behavior due to the circumstances—for example, the animal has learned the behavior, but it is a behavior only to be performed by the dominant animal, a case occurring very often in primates (Visalberghi, 1990). Or, in some cases, animals which have learned a behavior through observation may not engage in the behavior in favor of an easier one—i.e. pigeons having learned to peck open food wells by observational learning, when placed in flocks, will sometimes cease to exhibit this behavior in favor of scrounging food from the wells opened by others (e.g. Giraldeau & Templeton, 1991).

5.3. Innovative behavior

Finally, at the top of the pyramid, comes the ability to show innovative behavior. Primates comprise a large percentage of the research on this topic. White-faced capuchins (Cebus capucinus) have been observed to attack a poisonous snake with sticks, an instance in which the group was observed first barking at the snake, and then an adult male specifically hit the snake with a branch (Boinski, 1988). At the Gombe Research Station, chimps were observed to use leaves to move stinging insects and to use empty gas cans to make noise in threat displays (Goodall, 1986). Capuchins appear to learn nut cracking by trial and error, by banging together
things until they get the right combination (Visalberghi, 1987). Birds have shown many innovative behaviors, for example—obtaining food by flying past the automatic sensor to open a cafeteria door (Breitwisch & Breitwisch, 1991), stealing milk from a nursing seal (Johnston, 1973), and dropping shells, not to break them open, but to kill rabbits (Young, 1987). Male Bowerbirds are well known for their construction of elaborate structures to attract females, decorating them with shiny objects and elaborate designs (Griffin, 1992). One researcher witnessed beavers repairing major damage to a dam (Ryden, 1989), which Griffin (1992) later called “novel and appropriate responses to a wholly new situation without precedent in [the beaver’s] experience” (p. 98), and even guppies have been shown to complete novel foraging tasks (Laland & Reader, 1999).

6. Practical applications of creativity in animals

This framework can be applied to many practical situations. Researchers have struggled for decades to estimate the intelligence level of animals, and creativity may represent another way to gain insight into animal cognition. Indeed, just as recent findings suggest that creativity may be a less biased measure of intelligence in people (Kaufman, in press; Kaufman, Baer, & Gentile, 2004), might innovation give us more accurate insight into intelligence and an easier method of cognitive comparison across species?

Environmental enrichment is rapidly becoming required in zoos and aquariaums, yet there have been too few studies into the effectiveness of enrichment. One study found that rhesus monkeys demonstrated high levels of object use on the day an enrichment device (a stick or a simple toy) was introduced, but these levels decreased drastically by the second day (Line, Morgan, & Markowitz, 1991). Some researchers have suggested that rotation of enrichment objects is needed (Paquette & Prescott, 1988), but it is hard to know the level of elaboration actually needed. It may be possible that simple, less costly enrichment may be reused every other day and be just as effective as elaborate, high-priced enrichment. Without having basic research on an animal’s need for creative and new enrichment, current guidelines may be premature.

Some researchers are attempting to use novel sounds (such as “pingers”) to keep marine animals away from areas in which they do not belong, such as fishery nets. Research in the area has been varied; Cox, Read, Swanner, Urian, and Waples (2004) found mixed results: pingers reduced the number of dolphins actually being caught in nets, but they did not reduce the number of dolphins who initially approached the nets. Barlow and Cameron (2003), found pingers reduced both the total number of cetaceans and the total number of pinnipeds caught. Other researchers argue that using pingers to displace marine mammals may keep them from habitats which would ordinarily provide a source of food or shelter, or which contain ecosystems that rely on marine mammals as an apex predator (Carlström, Berggren, Dinnézet, & Börjesson, 2002). Learning how the novel sound of a pinger is interpreted could be vital information; it would be useless to set up an elaborate
device to keep dolphins away from fishery nets if they became desensitized to the novel noise within a short amount of time.

7. Conclusion

The study of creativity does not have to be confined to humans. By modifying our conceptions of the nature of creativity, wide-ranging behaviors such as the perception of novelty, social learning, and innovative acts can be studied. There are also many practical implications to studying creativity that may enhance the work of those who interact with animals on a daily basis, such as innovative training sessions, desensitization, and improvement of enrichment programs. Through the study of creativity and cognitive abilities in animals, and further research that may use the Three-Step Pyramid, we hope to gain insight into the larger questions of animal intelligence.

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References


