CHAPTER

13

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Of Course Animals Are Creative: Insights from Generativity Theory

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Commentary on Chapter 13: Defining Animal Creativity: Little-C, Often; Big-C, Sometimes

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Of course animals are creative, especially if one defines “creative” advantageously. That is easy to do, given that the word comes from the vernacular. That gives us a great deal of latitude in constructing our definition.

My favorite definition of creative, which works pretty well in most natural uses of the term but is by no means definitive, is as follows: “Creative” is how we label someone’s behavior or the product of that behavior if that behavior or its product is both *new* to some degree and also *of value* to a pertinent community. Sometimes, if someone behaves frequently and consistently in this way, we might even label the individual him- or herself “creative.”

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So if a child builds the same new and amazing block structure over and over again, we might say she was creative the first time she built it but probably not the second, and if the very first time she built it, she was simply copying someone else, again, it is unlikely we would label her behavior or the structure creative. If the structure is simple and boring, the language of creativity also won't usually be applied. Notable people in that child's community—a teacher, a parent, or a grandparent, typically—have to recognize the structure as intricate or interesting or esthetically pleasing. In other words, they have to *value* it before they will call it creative—generally speaking, the younger the child, the more relaxed the requirement.

The same criteria are generally applied to adults, even to accomplished adults such as artists and inventors. The main difference between judgments made regarding the creativeness of children and the creativeness of adults is the nature of the community. Mom or Dad have all the authority it takes to pronounce their child's artwork creative (but perhaps not the artwork of another child), whereas an adult writer or sculptor or inventor is at the mercy of a larger, more discerning panel of judges: critics, editors, art collectors, and so on—a panel that might even change from time to time, meaning that something that is judged creative by one community or in one generation might not be by another community or the next generation.

Novelty is still critical, however, no matter how generous the judges. No matter how squiggly Jackson Pollack's squiggles, if a dozen other artists had adopted his style before he did, his work would probably have been ignored—dismissed, perhaps, as copycat art, even if Pollack knew nothing of those other artists. So novelty is critical, and so is the community. In fact, one of the oddest things about the language of creativity is that one cannot credibly apply it to oneself. "Look, everybody—see how creative I am" does not impress and might even bring ridicule.

With these elements in mind, are animals creative? In this brief essay I will not only show that all animals are creative to some extent, I will also offer what I believe is an evolutionarily sound model for understanding why *both* animals and people behave creatively. Specifically, I will offer evidence that the same neural mechanisms, which can be expressed in formal terms using a theory I introduced in the 1980s called "generativity theory" (Epstein, 1985a, 1990, 1991, 1996a, 1999, 2014)—underlie the emergence of novel behavior in both animals and people.

THOSE AMAZING ANIMALS

In 1984, my colleagues and I reported that pigeons with appropriate training could solve Köhler's (1925) classic box-and-banana problem in a human-like, or, if you prefer, chimp-like manner, when faced with the problem for the first time. Like bright children faced with similar problems, our pigeons first looked confused for a while and then fairly suddenly solved the problem, pushing a box under a toy banana, climbing onto the box, and pecking the banana (Epstein, Kirshnit, Lanza, & Rubin, 1984). This kind of performance is not only novel—we could guarantee that, after all, by controlling and monitoring the behavioral histories of our pigeons—it also has obvious value. With animals, there is no community of peers available to judge a performance creative, but there is an obvious situation in which novel behavior demonstrates value: that is, when it solves a problem.

People have witnessed novel problem-solving behavior in animals for as long as they have been observing them, no doubt. Our family dog, Tiny Bryan, drove us all crazy for nearly a year by finding new ways to get through whatever gate we installed to keep her (yes, "Bryan" was female) out of our dining room, where she often left mementos on the carpet. Even more remarkably, none of us ever *saw* her get through a gate—never! So she not only was devising new ways to get through, she also had the good sense to practice her art only after determining that no one was observing her, just like Andy Dufresne in "The Shawshank Redemption." Brilliant!

Sometimes it was obvious that Tiny Bryan was using brute force because a gate was damaged, but most of the time we had no idea how she did it. When I installed an especially strong and tall gate, we were truly perplexed. Had she grown wings? My point is that with each new gate, our dog had to devise one or more new ways to get through.

In both laboratory and field settings, notable examples of novel problem-solving performances have been observed in many species, including dogs (e.g., Bräuer, Bös, Call, & Tomasello, 2013); all non-human primate species, to my knowledge, that have been studied (e.g., Avdagic, Jensen, Altschul, & Terrace, 2013; Boinski, 1988; Burkart, Strasser, & Foglia, 2009; Call & Tomasello, 1995; Capitanio & Mason, 2000; Fujita, Sato, & Kuroshima, 2010; Inoue-Nakamura & Matsuzawa, 1997; Kappeler, 1987; Menzel, Savage-Rumbaugh, & Lawson, 1985; Santos, Ericson, & Hauser, 1999; Tecwyn, Thorpe, & Chappell, 2012; Watson & Ward, 1996); elephants (Hart, Hart, McCoy, & Sarath, 2001), who are even said to be capable of exhibiting "insight" (Foerder, Galloway, Barthel, Moore, & Reiss, 2011); rodents (Tokimoto & Okanoya, 2004; Wass et al., 2012); marine mammals (e.g., Hille, Dehnhardt, & Mauck, 2006; Mann et al., 2008; Scholtyssek, Kelber, Hanke, & Dehnhardt, 2013; Schusterman, Thomas, & Wood, 1986); a wide variety of birds (e.g., Funk, 2002; Liker & Bokony, 2009; Pepperberg, 2004; Webster & Lefebvre, 2001); and even, to some extent, fish (Bshary, Wickler, & Fricke, 2002; Reader & Laland, 2000).

It is one of the great mysteries of comparative psychology that birds of the corvid family, particularly crows and ravens, are especially adept in this regard (e.g., Bird & Emery, 2009; Heinrich, 1995; Heinrich & Bugnyar, 2005; Hunt, Corballis, & Gray, 2001; Taylor, Elliffe, Hunt, & Gray, 2010; Taylor, Medina, et al., 2010; Von Bayern, Heathcote, Rutz, & Kacelnik, 2009; Wimpenny, Weir, Clayton, Rutz, & Kacelnik, 2009). It has even been argued that crows "understand their physical and social worlds" in much the same way that apes do, suggesting that convergent evolutionary processes are responsible for the extraordinary intelligence of both (Emery & Clayton, 2004, p. 1903; cf. Kirsch, Gűntűrkűn, & Rose, 2008).

In one of the more ambitious studies of this sort, seven New Caledonian crows (*Corvus moneduloides*) were presented with various tasks requiring the novel use of small sticks to retrieve food from one of two types of containers (Wimpenny et al., 2009). The tasks were varied, the authors stated, in order to determine the extent to which crows "understand" (p. 1) what they are doing and to shed light on the "cognitive mechanisms" (p. 1) underlying the performances. In what was clearly the most spectacular of the performances—and indeed the only one of its sort reported in the study—a crow dubbed "Betty" (i) immediately tried to reach a long stick (20 cm) that was out of reach in a transparent tube (this was spurious behavior, not relevant to the solution), (ii) picked up (with its beak) a short stick (6 cm) that was within reach, (iii) used the short stick to retrieve a medium-length stick (10 cm) from a different transparent tube, (iv) briefly tried to retrieve food from another transparent tube using the medium-length stick (also spurious behavior, given that the stick was not long enough to reach the food), (v) used the medium-length stick to retrieve the 20 cm stick from the first tube, and then (vi) used the long stick to retrieve the food. The entire performance, which was labeled "the first observation of spontaneous three-tool sequential tool use in a non-human animal" (p. 6), took about 53 s (cf. Epstein, 1985c, 1987; Epstein & Medalie, 1983).

The fact that Betty *immediately* tried to reach the long object upon flying into the test area suggests a long history of experience with respect to the sticks, and indeed, this was actually Betty's fourth trial in somewhat similar test situations, and she also had extensive experience with various sticks and tubes in a "pre-testing procedure" ("a minimum of 30 trials" plus "six familiarization trials" (p. 13)). The fact that Betty tried to reach the food with the medium-length stick also indicates that this was not a fully "reasoned" performance in the human sense.

Nevertheless, it was a novel performance that solved a problem, and in that sense it could be called creative. It was also unique among the other birds tested, meaning that Betty is very much like Sultan, Köhler's (1925) precocious chimpanzee that was able to solve the famous box-and-banana problem in an "insightful" fashion when five other chimpanzees, standing nearby, could not. Unlike Betty, however, Sultan was fairly inactive and looked pensive for several minutes before suddenly solving the problem. That period of quiescence is important, if only because it can be so easily interpreted in human terms.

Like other recent studies of this sort with corvids (e.g., Taylor, Elliffe, et al., 2010), the Wimpenny et al. (2009) study was designed to shed light on cognitive mechanisms, specifically by making predictions along the following lines:

a. *A lack of spurious actions would suggest that the birds were planning or reasoning*. But *all* of the birds tried at times to reach the food with the shortest stick, and even Betty, in her most impressive performance, reached at the wrong times for both the long stick and the food. Collectively, the birds made spurious probes with the short stick on at least 16 of 29 trials in the authors' first experiment.

b. *A correct choice of sticks would suggest that the birds were planning or reasoning.* However, generally speaking, "subjects did not appear to choose in advance the tools they required" (p. 5).

c. *When presented with the sticks but no food, a bird shouldn't bother manipulating the sticks, which would suggest that successful performances were truly "goal-directed."* But when a bird that had learned to retrieve sticks from tubes was confronted with this situation, although it never probed the empty food-tube with the shortest tool, it did use that tool "to extract further tools on all trials and used these to probe into [the food-tube]" (p. 6). In a subsequent procedure, "all subjects did insert an extracted tool into the (empty) food-frame on at least one trial" (p. 9).

d. *If birds without relevant experiences with sticks could solve the problem, that would suggest they were capable of advanced reasoning abilities.* But in the authors' first experiment, all three of the birds that lacked experiences with sticks "failed in all tasks where tools had to be extracted" (p. 6). In a second experiment, one bird "used a tool to extract another tool on his very first trial" (p. 12), but it wasn't able to retrieve food with any tool. Moreover, one bird "frequently took the extracted tools to other parts of the aviary, suggesting that, although crows responded to some extent appropriately to the contingencies of the task, they were motivated to extract tools *per se*" (p. 9).

Although the authors argued that the number of errors they observed in some situations was less than one might expect by chance, overall, they offered little evidence of any substantive cognitive activity in their birds, and, indeed, they were forced to conclude that "we do not implicate reasoning (or a lack of it) as an explanation for our crows' behavior" (p. 12).

Other researchers, reviving the old debate about behaviorism that began more than a century ago (see King, 1930; Watson & McDougall, 1928), have taken various stands on this issue, some insisting that problem-solving performances in animals demonstrate clear signs of human-like cognitive activity (e.g., Taylor, Elliffe, et al., 2010), others taking a more conservative stand (e.g., Shettleworth, 2009, 2010). This debate has never yielded a winner and never will; it is pointless, in my view (Epstein, 1984, 1996a, 2014).

ANIMAL ART

In judging the creativeness of animal behavior, we needn't limit ourselves to problem solving. Novel human behavior can be judged to be creative, after all, if it has virtually *any* kind of value—esthetic (think Michelangelo), economic (the first Apple desktop computer), or even just bizarre (Lady Gaga). Non-human animals lack a linguistic community capable of judging their behavior to be creative, but that doesn't mean humans can't step up to fill the void. Oddly enough, even pigeons can be trained to discriminate good human art from bad human art (Watanabe, 2010). It should be a simple matter for us to make similar discriminations regarding animal creativity.

Are there examples of novel animal behavior that humans might reasonably judge to be creative? A YouTube video that has had nearly 10 million views shows an elephant named Paya, a resident at the Maesa Elephant Camp in Chiang Mai, Thailand, painting a fairly simple but beautiful image of an elephant holding a flower.[1] Unfortunately, this performance will not satisfy our definition of creative, because Paya was painstakingly *trained* to paint this image over and over again every day to entertain tourists, and he was also probably coached during the making of the video.[2]

Other elephants, however, given more of a free trunk (so to speak), have occasionally covered canvasses with images impressive enough to draw large sums from human art collectors (Bourgeois, 2005; Suttle & The, 1997). A 2012 exhibition at the University College London's Grant Museum of Zoology displayed paintings by elephants, gorillas, orangutans, chimpanzees, and even a bowerbird which many people would consider to be indistinguishable from comparable human art (Guerke, 2012).

Not every painting by a particularly talented elephant is praiseworthy, but the same can be said of the paintings of human artists. Years ago, I had the pleasure of viewing Andrew Wyeth's "Helga" exhibit at

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[1] http://www.youtube.com/watch?v=He7Ge7Sogrk.

[2] http://urbanlegends.about.com/library/bl_elephant_painting.htm.

a museum in Boston. This was one of the most unique art exhibits of its day, because the collector who bought the completed paintings insisted on buying and having the right to preserve and show more than 200 preliminary drawings and studies that preceded the finished works, some so crude that a young child—or chimp—could have made them. We are willing, in short, to judge someone creative if he or she behaves creatively only occasionally. If we give the same latitude to animals, we will almost certainly judge many animals to be creative.

GENERATIVITY THEORY

Whether novel animal behavior has value in the same sense that novel human behavior has value is debatable, just as the significance of computer-generated art and music is debatable, or even the significance, for that matter, of any computer behavior that seems to mimic human intelligence (Epstein, Roberts, & Beber, 2008; Turing, 1950). But the fact that animals do new things is indisputable. Where does novel behavior come from, and is it possible that the same basic processes are responsible for the novel behavior of both animals and people?

In the early 1980s, I proposed a theory to try to explain the emergence of novel behavior in multiple species. According to generativity theory, (i) new behavior emerges as previously established repertoires of behavior become interconnected over time, and (ii) the interconnection process is both orderly and predictable. Combinatorial theories of creativity have been around for a long time (consider Hull, 1935; Poincaré, 1946; Rothenberg, 1971); the main thing I added to the picture was an assertion of orderliness, as well as a way of quantifying and measuring this orderliness. Specifically, I speculated that multiple processes operate simultaneously on the probabilities of multiple behaviors, and, by implication, on their underlying neurological systems.

This is a sensible and, in some respects, simple theory. It is also predictive and parsimonious. Most important for present purposes, generativity theory explains why novel behavior—a small portion of which will inevitably have value in specific situations—is ubiquitous in the animal kingdom. The orderly and rapid interconnection of repertoires of behavior is *adaptive*; it is about as adaptive a process as nature could possibly devise because it guarantees that all previously established behaviors, whether learned or programmed by genes, will be available to tackle new challenges as they arise moment to moment in time in the environment. Generativity theory shows how this process works without making any assumptions about speculative cognitive mechanisms—or denying their existence.

The same mechanisms underlie the emergence of novel behavior in both animals and people because novelty-yielding behavioral variability has value, just as novelty-yielding genotypic and phenotypic variability have value in evolution. Species survive and sometime diverge because of phenotypic variants. The range of variability in traits yielded by sexual reproduction is so large that genuinely new traits inevitably emerge in every generation—a phenomenon that helps to protect a species from extinction when environmental conditions change and that ensures that superior traits and even superior species will ultimately triumph over time. Similarly, novelty-yielding behavioral variability in an individual organism helps to guarantee that that individual's behavior will be effective under changing conditions, occasionally even producing behavior so new that it can change the organism's environment in significant ways.

These two types of variability might even overlap. Genes might occasionally produce individual organisms so creative that they find effective new ways to compete against other species for limited resources, eventually dislodging those species from the gene pool.

Two ubiquitous situations in the natural environment assure that behavioral competition occurs almost continuously. First, the real world surrounds us constantly with multiple, novel, and vague stimuli which set multiple behaviors in motion. Second, when behavior is ineffective—which it is in small ways hundreds of times a day—a process called "resurgence" occurs: previously established behaviors that were effective under conditions similar to the current ones are activated (Epstein, 1983, 1985b, 1996a; cf. Epstein & Skinner, 1980). Generative processes thus assure not only that behavior will *vary* but that it will vary in ways that are especially likely to be adaptive in the current situation. In this sense the variability that occurs in individual organisms is even more adaptive than the variability that drives the evolution of species; the latter is blind, but the former guarantees the emergence of new behavior that is specifically relevant to the properties of the new situation. Generativity theory also has immediate practical value, because when you identify variables and parameters that contribute to the emergence of novel behavior, you can manipulate those variables and parameters for useful ends (Epstein, 1996b, 2000, 2011; Epstein, Kaminaka, Phan, & Uda, 2013; Epstein & Phan, 2012; Epstein, Schmidt, & Warfel, 2008).

To explore the potential power of generative competition, I expressed the theory in formal terms and modeled it with a computer algorithm. Representing just four long-studied behavioral processes in a series of equations I called "transformation functions" (Figure 13.1), I was able to model a number of creative performances I had studied in laboratory settings with both pigeons and people, such as the manner in which

(1) *Extinction:* $y_{n+1} = y_n - y_n * \varepsilon$

(2) *Reinforcement:* $y_{n+1} = y_n + (1 - y_n) * \alpha$

(3) *Resurgence:* for $\lambda_{yy'} < 0$ and $y'_n - y'_{n-1} < 0$,
$y_{n+1} = y_n + (1 - y_n) * (-\lambda_{yy'}) * y'_n$

(4) *Automatic Chaining:* for $\lambda_{yy'} > 0$ and $y'_n - y'_{n-1} > 0$,
$y_{n+1} = y_n + (1 - y_n) * \lambda_{yy'} * y'_n$

FIGURE 13.1 **The transformation functions of generativity theory.** According to generativity theory, multiple behavioral processes operate simultaneously on the probabilities of multiple behaviors. In one possible instantiation of the theory, four basic behavioral processes are represented (above). y_n is the probability of behavior y at cycle n of the algorithm, y'_n is the probability of behavior y' at cycle n of the algorithm, ε is a constant for extinction (it determines the rate at which the probability of behavior y decreases over cycles of the algorithm), α is a constant for reinforcement (it determines the rate at which the probability of behavior y increases over cycles of the algorithm as a result of certain environmental events), and $\lambda_{yy'}$ is the constant of interaction between behaviors y and y'.

people solved Maier's (1931) classic "two-string problem" (Figure 13.2). Running simultaneously in a "state" algorithm, the transformation functions generate a "probability profile," in which overlapping probability curves show how behavior changes over time, producing novel behavior almost continuously as other behaviors become interconnected over time (Figure 13.3). I also devised a way to show the orderliness in the novel performance of a single subject using a graphical technique that generates a "frequency profile." The frequency profile yields overlapping curves that look very much like probability curves (Figure 13.4).

This methodology proved effective in predicting novel performances in both pigeons and people in laboratory performances. The differences between the two species seem largely to be parametric. The general principles—that new behavior emerges as old behaviors merge and that multiple behavioral processes operate simultaneously on the probabilities of different behaviors—seem valid for both species and perhaps for many others as well.

The formal representation and quantification of the creative process in individual organisms is no small feat, but with few exceptions the existing literature on animal creativity and problem solving shows little or no awareness of any of the main implications of generativity theory and its supporting research. Instead researchers are (and I say this respectfully) wasting their time debating about what animals may or may not "understand" regarding their performances, as if that information—were it even possible to determine with any degree of confidence, which it is not—would add anything important to our own "understanding" of the performances.

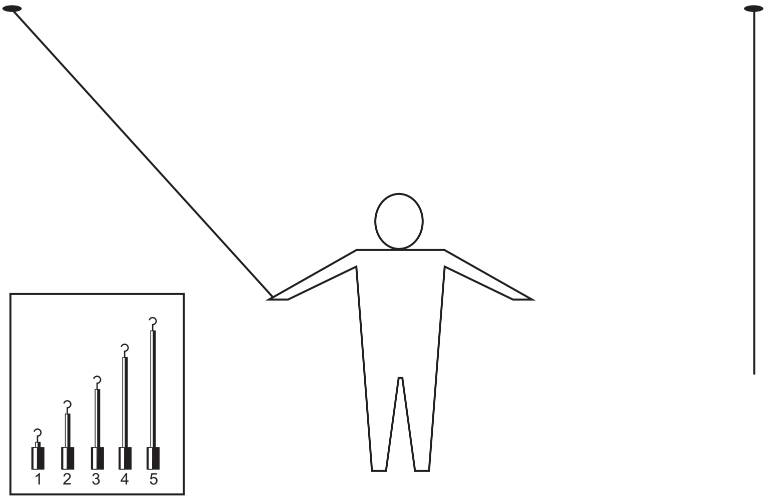

FIGURE 13.2 Maier's (1931) **Two-string problem.** Subjects are instructed to tie the two ends of the strings together, but they quickly learn that they can't reach both strings at once. They learn this by pulling one string toward the other and reaching. Most people then try pulling the second string toward the first, which makes little sense. When provided with a long heavy object (#5 in inset), a subject is highly likely to use it to extend his or her reach, but the object that is provided is not long enough to reach the other string. When provided with a short heavy object (#1), a subject is much more likely to solve the problem, which requires tying the object, short or tall, to one string and swinging it, then pulling the other string toward the swinging string and catching it when it comes near. Appropriately, the problem is sometimes called "the pendulum problem." Provided with a long object, if a subject is able to solve the problem at all, automatic chaining is usually involved. The person ties the long object to the end of a string and then pulls the object toward the second string; this is one way of using the object to extend one's reach. When that fails, the subject often lets go of the object, which causes the attached string to swing in a pendulum motion. The solution follows rapidly. Objects of intermediate lengths produce predictable outcomes according to those lengths.

When you speculate about what an animal "understands" regarding an arrangement of stimuli or the manner in which it solved a problem, you are simply talking about *more behavior*. You are asking whether the animal can not only solve the problem but can also *state a principle* or *visualize a causal flow diagram* or perhaps even *perform mathematical calculations*. The problem here—which has existed as long as comparative psychology has existed—is that *as long as you can conceive of a way for the animal to have solved the problem without engaging in these so-called "high-level" cognitive manipulations, you must make the parsimonious assumption that the animal is not doing so.*

Even if we were able to show definitely that an animal had formulated the (human) verbal equivalent of a formal principle, I have little doubt that the processes giving rise to the emergence of such a

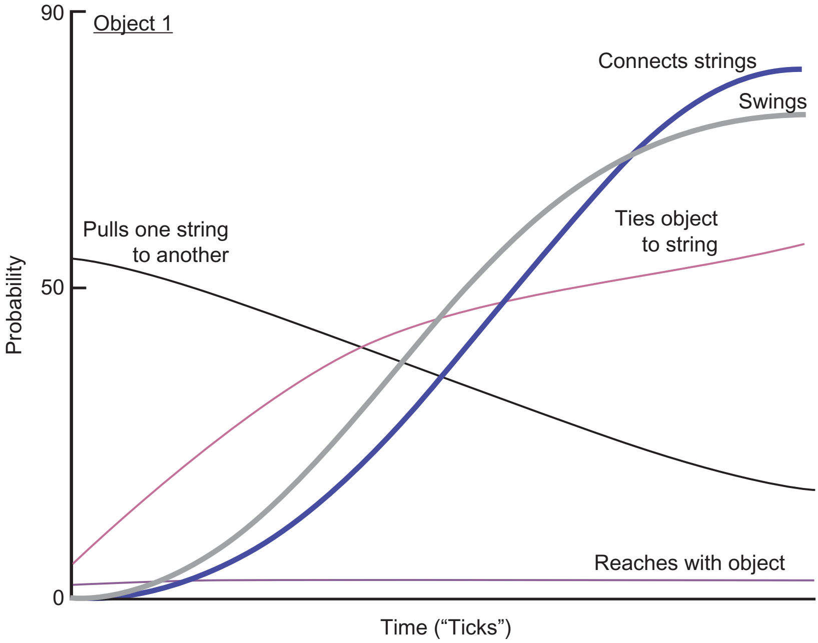

FIGURE 13.3 **Probability profile for Maier's (1931) two-string problem.** A probability profile generated by the transformation functions shown in Figure 13.1, generated for five behaviors relevant to Maier's (1931) two-string problem. The abscissa is labeled "ticks," which are cycles of the computer algorithm, each a scalable moment of unspecified duration. The profile was generated with parameters for a short object (#1 in Figure 13.2), which generally produced rapid solutions to the problem and no irrelevant reaching. Note that pulling one string toward the other decreases steadily in probability and that other behaviors increase in probability in an orderly sequence. Tying the object to the string makes swinging more likely, which, in turn, makes connecting the strings more likely. The computer model that generates the curve uses discrete state methodology, running a set of initial probabilities through all four equations to generate a new set of probabilities, then running those through the equations again, and so on.

principle—again, this is just more behavior, after all—would be similar if not identical to the processes that led to the emergence of the problem-solving performance itself. In footnote 5 of an early paper I published on the principle of resurgence, I explained how generative processes—in particular, the process of resurgence itself—could account for my formulation of the formal principle of resurgence itself (Epstein, 1985b, p. 151; also see Epstein, 1996a, p. 145). A statement of a relationship among variables—in other words, "reasoning"—is, first and foremost, a *statement*; again, it is just more behavior, presumably amenable to the same sort of analysis that can be applied to all behavior.

Without exception, all of the studies of animal problem solving or creativity I have seen in recent years lend themselves to a rigorous

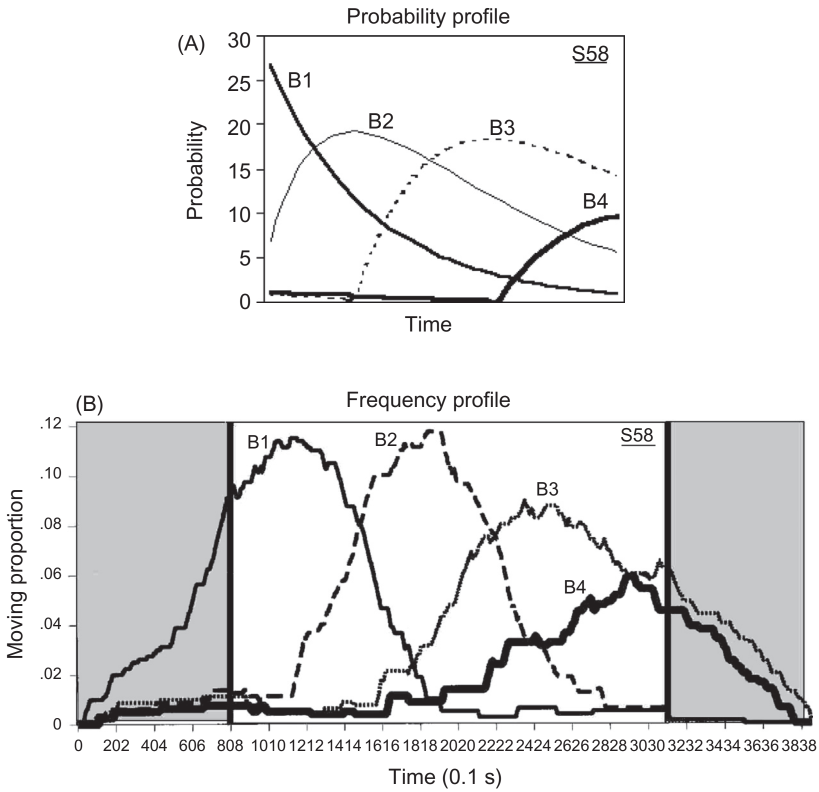

FIGURE 13.4 **Predicting individual behavior moment to moment in time.** (A) This probability profile, produced by the transformation functions of the generativity model, predicts the behavior of a human subject on a touch-screen task. The subject has been instructed to move a spot across the screen into a goal area. Tapping three patches on the screen (B1, B2, and B3) will move the spot in various directions and at varying speeds; tapping a fourth patch (B4) has no effect. The model predicts that the subject will begin tapping B1, then gradually shift to B2, then gradually shift to B3, with responses alternating among the three choices along the way (where the curves overlap). It also predicts that toward the end of the session, the subject will begin tapping B4, even though doing so has no effect. (B) This frequency profile shows actual data obtained from one subject (S58) during a 5 min session. The pattern of responding is predicted well by the probability profile, including the shift to B4.

analysis using the tools of generativity theory. Video recordings can be examined frame by frame, coded, and represented by frequency profiles, which instantly reveal orderliness which is almost entirely invisible to the naked eye. Instead, researchers are still relying on crude verbal descriptions of the performances, or, at most, rough tabulations of "percentage correct" and other data aggregated across organisms or trials. Problem situations, which by definition, are bounded in specific ways, can easily be represented in formal terms using transformation functions, and those functions can then be used to model and predict individual performances. In short, the orderliness in animal creativity can be quantified and studied rigorously using advanced tools of the natural sciences.

Whether generativity theory is correct in its particulars is beside the point. The predictive power of this type of theory is so great that some form of it almost certainly must be correct. Almost certainly, multiple processes must be acting simultaneously on the probabilities of multiple behaviors and their counterparts in the nervous system, and the net result generates a wide range of behavior continuously in time—everything from mundane grooming to profound "insight."

Meanwhile, many researchers in psychology and biology who are rightfully fascinated by some of the extraordinary human-like capabilities of crows, chimpanzees, and other animals, are barking up the wrong tree. Like the naturalists of the 1800s, they continue to anthropomorphize, insinuating that human-like performances by animals are interesting only if an animal's cognitive world is like a human's.

Meanwhile, I wonder, as many have before me, why we continue to bother speculating about the cognitive world of *humans*; I have long seen this as a dilemma in which our consciousness interferes with our scientific objectivity (Epstein, 1982, 2008).

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Commentary on Chapter 13: Defining Animal Creativity: Little-C, Often; Big-C, Sometimes

Epstein’s (this issue) main argument has already been emphatically endorsed in my *Origins of Genius: Darwinian Perspectives on Creativity*