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5 Bringing Cognition and Creativity into the Behavioral Laboratory

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Four categories of complex behavior have traditionally given praxists[1] trouble and, not surprisingly, have stimulated theories about cognition and creativity.

Novel Behavior. The most perplexing has been novel behavior. Humans and other organisms do things they have never done before and, occasionally, things no member of their species has ever done before. The mystery of novelty underlies most theories of creativity and has spurred such concepts as "generativity" in language production (Chomsky, 1965) and "productivity" in problem solving (Wertheimer, 1945).

Delays. Second, behavior often appears to be under the control of events that occurred in the remote past. Köhler (1925) notes a case in which some food was buried outside a chimpanzee's cage in full view of the chimpanzee. When the animal was released the next morning, it immediately unearthed the food. Few people would be content to speak of action at a distance in this situation, in part because we know that intervening events can change the outcome. Clearly, environmental events change organisms, and the changes often manifest themselves in subsequent behavior, even after long intervals of time have elapsed. We know very little about what those changes are. Meanwhile, control of behavior by temporally remote stimuli spurs theories of "memory."

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[1] *Praxics*—a blend of "physics" and "praxis," the Greek for "behavior"—is a term I and others now use for the study of behavior. *Behaviorism*, properly speaking, is the name of a school of philosophy. For a fuller discussion of this terminology, see Epstein (1984d).

Covert Activity. Third, thoughts, feelings, and so on are accessible only to oneself, and as long as that remains the case, speculative theories about their nature and significance will flourish.

Complex, Distinctively Human Behavior. And finally, complex human behavior, such as language, or the behavior attributed to a self-concept, is often difficult to account for. When an environmental or biological account of distinctively human behavior is not apparent, people often appeal to a construct. Only humans sing "The Star Spangled Banner," but because one is taught in a conspicuous way to do so as a child, we don't bother with a construct. In contrast, many would insist that Francis Scott Key's composition, which is not easily traceable to either biological or environmental factors, was a product of creativity and various cognitive processes.

Creativity

Creativity is a natural category and, as such, is probably not worth trying to define (Epstein, 1980).[2] It is, moreover, a particularly elusive one. It is a judgment pronounced by a community on behavior or a product of behavior, and like all such judgments (for example, of "morality" or "beauty"), it differs from one community to the next and changes from time to time. A cubist painting would not have been judged creative in 15th-century Europe; it would have been burned. Western music critics wouldn't presume to be able to judge the creativeness of a traditional Japanese composition without special training in the criteria the Japanese use to make such a judgment.

The judgment also depends on who did what first. If Einstein had emerged from the patent office only to find that others had already proposed the theory of relativity, Wertheimer (1945) would not have bothered to determine what was so productive about his thought processes. Deviance alone is not sufficient for the judgment of creativity; it must be deviance that is valuable to other people.

The elusive judgment, furthermore, once made, can be retracted. A current popular song was no doubt judged a creation of the composer until he lost a plagiarism suit. The scientific works of a young academician were no doubt judged creative before it was discovered that he had stolen some of them from fellow scientists. Computer-generated poetry is never judged to be creative once its origins are revealed. The more we know about the sources of behavior, the less inclined we are to speak of creativity, or, to paraphrase Samuel Butler, creativity is only a word for man's ignorance of the gods.

Such a concept does not seem suitable for the laboratory. What is worth studying, however, is novelty. Novel behavior has to occur before a community can select some of it and call it "creative." Why it selects some and rejects others is no mystery; novelty itself is the mystery.

Sources of Novelty

At least four sources of novelty are readily accessible to laboratory study. Two—imitation and instructions—are social phenomena that involve conspicuous controlling stimuli; the others—variation and the spontaneous interconnection of repertoires—are individual phenomena that seem to be responsible for novelty's air of mystery. A discussion of these phenomena must be preceded by at least a few words about a rather troublesome problem: How do we *measure* novelty?

Measurement. If we look only at behavior, our determination will be constrained by our level of observation. If we look at behavior too closely, we will judge all behavior to be novel, for we never do exactly the same thing twice. A rat sometimes presses the lever with one paw and sometimes with the other, and presses constantly vary in force and duration. We often seem to be repeating something we have done before, but that is only because we are so insensitive to detail (Epstein, 1982a). The same word, spoken twice, leaves easily distinguishable records on a spectrogram. Even an identical repetition could still be judged novel, because it is both unique in time and the product of a changed organism; as William James (1890) noted, we don't call two ticks of a clock the "same" tick.

On the other hand, if we overlook too much detail or summarize over too long a period of time, we will judge very little behavior to be novel. We would take no notice, for example, when Mozart sat down to write a symphony if he had already written one before. This is the problem addressed by Skinner in his "Generic Nature" paper in 1935, but his solution, unfortunately, is not applicable here, for we are not interested in a recurring unit of behavior but simply in one special instance.

Topography, in general, might mislead us, no matter what our level of analysis. A painter's hand may have moved (more or less) in every possible way it could have moved before she began work on the canvass before her. What will make this work unique is a new sequence of strokes. Perhaps, in our determination of novelty, our focus should be on new combinations of old behaviors.

Still other complications present themselves when we look exclusively at behavior: Is smoother or more forceful motor performance "novel"? How should we treat apparently "random" changes in behavior? One alternative is to look at the product of behavior, which is what researchers have tended to do (e.g., Goetz & Baer, 1973). We can in so doing establish fairly objective criteria for novelty suited to our domain of interest. We can look for uncommon words in a composition, for example, or block structures greater than a certain height, or new color combinations in a drawing. Though response product is a convenient

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[2] Catania (1979) justifiably makes the same point about the word "learning."

measure, objective measures of behavior itself will be helpful in cases in which the relevant behavior is observable and in which observations are made at an appropriate level (e.g., Maltzman, 1960; Schwartz, 1980).

Imitation. One important source of novelty is a social process—imitation. If you can do something you have never done before just because you see someone else doing it, you are capable of infinitely more behavior than you would be otherwise. Most of the novel behavior a child exhibits is imitated: blowing on hot food, playing "patty cake," turning door knobs, and so on. And as any linguist will attest, in the early years most words are acquired through imitation. Imitation can be either innate or learned; it can be specific to certain behaviors or generalizable to many; and it can occur either soon after a model has behaved or after a substantial delay.

Both innate and learned imitation have been studied as part of the Columban Simulation Project (Baxley, 1982; Epstein, 1981, 1984a).[3] Experiments on learned imitation revealed that pigeons imitate each other to some extent even without training (Epstein, 1984b).[4] Several experiments have been conducted in which a naive pigeon on one side of a clear partition watches a pigeon on the other side peck a ping pong ball, pull a rope, or peck a key for food reinforcement. Given access to similar operanda, the naive pigeon will imitate the leader at a low rate day after day without any reinforcement. Moreover, it will subsequently continue to peck or pull for several sessions without a leader present.

Instructional Control. A second source of novelty in human behavior, also a social process, is instructions. The first time we drive a car or play the piano or bake a cake, we are usually following instructions. We could simulate the effect of instructions in producing new behavior by bringing several different responses under the control of different discriminative stimuli and then presenting the stimuli in new orders or by bringing the force of a response under the control of the size of some stimulus and then making the stimulus smaller or larger than it

ever was before (cf. Catania, 1980). Human language will be considerably more powerful in this capacity than anything we can simulate with pigeons.

Variation. A third and in many respects the most fundamental source of novelty is variation, nature's own source of novelty, both at the ontogenic and phylogenic levels. We speak of classes of responses, just as taxonomists speak of classes of organisms, because—although it is true that the same response never occurs twice—related responses covary. Like Darwin, we depend on variation to account for novelty, at least in some instances, and again, like Darwin, we know nothing about the underlying mechanism. We also depend on variation to produce novel behavior: We are able to "shape" behavior only because there is always a distribution of responses from which to make a selection. As long as the response we reinforce is not near the mode of the distribution, a new distribution will appear from which we can make another selection. By continuing to strengthen infrequent responses, we can eventually produce behavior that has never occurred before, as when we gradually increase the force requirement for a lever press in a classroom demonstration until a rat presses with a force equal to its own weight. Relatively little research has been done on variation per se; it is simply a fact about behavior which we make use of daily but which is otherwise quite mysterious.

Interconnection. A fourth source of novelty is a phenomenon we might call "the spontaneous interconnection of repertoires" (cf. Hull, 1935). Separate repertoires of behavior can come together in new situations to produce blends, new sequences of behavior, or—by bringing an organism into contact with new contingencies—behaviors that have new functions. This is in many respects the most dramatic and mysterious source of novelty and is probably responsible for much of the behavior people call creative in science and the arts, as well as certain productive aspects of language (Place, 1981).

Several popular and highly speculative theories of creativity describe a similar process: Writer Arthur Koestler (1964), for example, attributed creativity to something he calls "bisociation," which is "any mental occurrence simultaneously associated with two habitually incompatible contexts." Rothenberg (1971), a psychiatrist, said that creativity is based on what he calls "Janusian thinking" (from Janus, the god with two faces), which is the ability "to conceive and utilize two or more opposite or contradictory ideas, concepts, or images simultaneously." Norman Maier (1929), a Gestalt psychologist, defined "reasoning," which was to him a creative process, as "the combination of isolated experiences." The mathematician Poincaré (1946) spoke of the collision of ideas, rising into consciousness "in crowds" "until pairs interlocked" in accounting for some of his achievements.

The combinatorial process just described is less speculative than the latter four, but if it works in covert behavior the way it works in overt behavior, it may

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[3] The rationale for using pigeons in such experiments is given at length elsewhere (Epstein, 1984a). Carefully constructed simulations of complex human behavior with nonhuman subjects can provide "plausibility proofs" of the role that certain environmental histories play in the emergence of the behavior. In some cases more definitive research cannot be conducted, usually for ethical reasons. The plausibility of such simulations rests on five factors: the topography of the behavior, the function of the behavior, the structure of the organism, the generality of the behavioral processes invoked, and evidence that humans have had the relevant histories. Not all the studies referred to in the present chapter meet these criteria. For a fuller discussion of these and related issues, see Epstein (1984a). The rationale is briefly stated in Epstein (1981).

[4] There is a previous report of spontaneous imitation in pigeons (Zentall & Hogan, 1976). In that report, however, the observing animals were technically not "naive," because they had been hopper trained, and the observed effect was small. There are perhaps hundreds of other investigations of both innate and learned imitation in both animals and humans (e.g., see Flanders, 1968; Miller & Dollard, 1941; Porter, 1910; Thorpe, 1963).

be just the process about which Koestler and others were speaking. The spontaneous interconnection of repertoires is actually surprisingly accessible to laboratory study. It has occurred in a number of the Columban simulations. One was called "The Spontaneous Use of Memoranda" (Epstein & Skinner, 1981), which was a follow-up of the symbolic communication demonstration we did with Jack and Jill (Epstein, Lanza, & Skinner, 1980). After we established the original exchange, we changed the positions of the birds until each had acquired both the "speaker" and "listener" repertoires. Among other things, each subject had now learned to pair colors (red, green, and yellow) with letters (R, G, and Y) and letters with colors. When the partition that had separated Jack and Jill was removed and one bird was given access to both response panels at once, a new sequence emerged without our intervention: Those parts of the speaker and listener repertoires which were successful in this new situation became interconnected to form a new chain. A bird would peck a color hidden behind a curtain, peck (and thus illuminate) the corresponding black-on-white letter, cross to the other side of the chamber, *look back* at the illuminated letter, and, finally, peck the corresponding color key.

The repertoires that had been established prior to the test not only provided the makings of the new sequence, they also brought the pigeon into contact with new contingencies, according to which a peck at a letter key now served a new function—that of mediating the delay between a peck at the hidden color and a peck at a corresponding color on the other panel. Without providing any additional training, we conducted a series of tests over a 5-month period which indicated that these pecks were indeed functioning as memoranda. When the task was made easier, for example, the pigeons stopped pecking the letter keys; when the task was made more difficult, they began pecking them appropriately once more. When Jack was distracted by a loud noise before a peck at a color key, he would start and then *look back* at the illuminated letter key before pecking the corresponding color key.

An even more striking example of the spontaneous interconnection of repertoires occurred in our experiment on "insight" (Epstein, 1981; Epstein, Kirshnit, Lanza, & Rubin, 1984). A pigeon was trained both to push a box toward a target and to climb into a stationary box and peck a small toy banana. When the banana was placed out of reach and the box placed elsewhere on the floor of the chamber—a situation very much like the one with which Köhler (1925) confronted his chimpanzees—the two repertoires occurred one after the other, and hence the pigeon "solved the problem." We have conducted this experiment now many times and have varied the training histories to determine the contributions of a number of different experiences. For example, if brute force attempts to get at the banana by flying and jumping are extinguished before the test, the solution may occur rather quickly (in about a minute, for several birds). If such behavior is not extinguished, the pigeon will first attempt to reach the banana by brute force, as did Köhler's chimpanzees.

On the basis of various controls we have completed so far, we can give a tentative, moment-to-moment account of a successful performance. The test situation is a new one for the bird, so at first there may be very little behavior and then what appears to be competition between the climbing and pushing repertoires (stimuli are present which control both repertoires).[5] The bird manages to look "puzzled": It looks back and forth from banana to box, stretches toward the banana, motions toward the box, and so on. At some point the bird starts to push the box. If it had been previously trained to push the box toward a small green spot at the base of the chamber—one training scenario—it very clearly starts to push the box *toward* the banana. This, it now appears, is a matter of generalization, though not based on physical similarity but rather on the fact that behavior with respect to both the green spot and the banana had been reinforced. A bird trained to push the box toward the green spot but not to peck the banana or climb on the box did not push the box toward the banana when the banana was placed out of reach in the chamber.[6]

Once the bird has pushed the box in the neighborhood of the banana, it has arranged for itself a new stimulus—box under banana—which is the occasion upon which the second repertoire, climbing onto the box and pecking the banana, had been reinforced. We call this process "automatic chaining," because the bird has automatically arranged the discriminative stimulus for the second link of a two-component chain.

Reinforcement. I have mentioned four sources of novelty but have managed to omit reinforcement. Psychologists have been using reinforcement to promote novelty for decades (e.g., Goetz & Baer, 1973; Maltzman, 1960); isn't it a source of novelty? Reinforcement, I submit, is probably not a source of novelty per se but rather: (1) It may stimulate activity and in so doing increase the amount

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[5] Multiple repertoires can be made available in several ways. The first, which seems to apply in the version of the box-and-banana experiment just described, is multiple controlling stimuli: Compound, ambiguous, and novel stimuli should increase the likelihood of all the behaviors controlled by their constituents. There is some evidence that this is an orderly, quantifiable process (Cumming & Eckerman, 1965; Migler, 1964). A second phenomenon is the resurgence of previously reinforced behavior during extinction (Epstein, 1983, 1985a; Epstein & Medalie, 1983; cf. Epstein & Skinner, 1980; Hull, 1934; Leitenberg, Rawson, & Bath, 1970; Maltzman, 1955; Staddon & Simmelhag, 1971). Resurgence during extinction may be one of the most important determinants of behavior that is often mistakenly labeled—even by me—"spontaneous" (e.g., Epstein & Medalie, 1983; Epstein & Skinner, 1981).

[6] I have tested this interpretation by repeating the test with two other birds who have had such training and then testing them again after they have been trained to peck the banana. The pigeons pushed more directly toward the banana in the second test. Similarly, a child who has spotted a cookie jar on a table and then retrieved it by pushing a chair toward the table and climbing on the chair will more likely do so the next day to retrieve a toy car than to retrieve a roll of toilet paper, though the latter more closely resembles the cookie jar. Such behavior suggests a process akin to what some describe as "functional" categorization (e.g., Bruner, Goodnow, & Austin, 1956).

of variation we see in behavior. But almost any stimulus will do that; it needn't be a reinforcer. (2) By strengthening one response over another from the distribution of available responses, it can produce a new distribution in which, because behavior varies, new behavior occurs. Variation is the actual source of novelty in this case (cf. Fenner, 1980; Staddon & Simmelhag, 1971). (3) It can serve to establish a discrimination between what is new and not new. Given reinforcement, for example, for building novel block structures, a child would come to preserve structures that he (or she) hasn't seen before and destroy or alter structures like those he had already built. Similarly, if income and recognition are contingent on originality, an artist might push aside or alter a design that resembles that of another artist or another of his or her own works. Schwartz's (1980) finding that pigeons cannot learn to emit novel sequences of pecks indicates only that he could not establish the discrimination between old and new sequences, not that pigeons are incapable of significant novel behavior (cf. Pryor, Haag, & O'Reilly, 1969).

"Promoting Creativity." Arieti (1976), Guilford (1950), Koestler (1964), Maltzman (1960), Osborn (1953), Skinner (1970, 1981), Torrance (1962, 1963), and many others have offered techniques for "promoting creativity." Many techniques, such as brainstorming, free association, spending time alone, daydreaming, "free thinking," and inactivity, provide circumstances under which behavior is free to vary or old behaviors are likely to come together in new ways.

Measures of Mind

In their influential text on theories of learning, Bower and Hilgard (1981) ask, "Do behaviorists confuse the subject matter of [psychology—which is to say, cognition] with the evidence available for drawing inferences about this subject matter?" (p. 211). A sentence or two earlier they query, "Is physics the science of physical things or the science of meter readings?" The rhetoric is misleading.

Let us assume that physics is indeed the science of physical things.[7] Praxics would seem to have a lot in common with it, for analysts of behavior use meters (videotape recorders, computers, cumulative recorders, event recorders, and so on) to measure physical things—events in behavior and the environment.

Hilgard and Bower overlook the fact that physicists use measuring devices, not to make inferences about physical things, but to measure them. The things they measure presumably exist. Praxists do the same. It is the cognitivists who are doing something unique—that is, using measuring devices to measure events in behavior and the environment, and then using the obtained measurements to speculate about a domain that can never be directly measured and whose very existence is uncertain.

("Cognition," after all, is just a nine-letter substitute for a four-letter word. What they're really interested in is Mind.)

Reaction Time. The problem of measurement is not a trivial one for cognitivists, for there must always be some doubt about whether their measurements are making contact with the mental phenomenon in which they are interested. The problem is exemplified in the use of reaction time to make inferences about mental processes.

Oswald Külpe, a student of Wundt's, struck a near-fatal blow against the use of reaction time in his *Outline of Psychology* in 1893. Donder's subtraction procedure, he argued, is valid only if complicated tasks, such as discrimination or choice, preserve the simpler components of which the complicated task is supposedly composed. There is no way to know a priori that this is the case, because direct measurement of the processes is impossible. As Woodworth (1936) later put it, "Since we cannot break up the reaction time into successive acts and obtain the time of each act, of what use is the reaction time?" (p. 309). Külpe and contemporaries were also disturbed by contradictory and unreliable results. With the emergence of functional and behavioristic psychologies in the first two decades of this century, the use of reaction time as a means of inference about cognition lost its popularity.

With the rise of cognitive psychology in the 1950s and 1960s, however, reaction time has come into use again and in fact may now be psychology's most popular measure of behavior. But the old problems have not gone away. Because the object of study can never be measured directly, the same data are always subject to more than one interpretation. Consider the debate that has been raging since the 1950s about whether perception works by template matching (Selfridge & Neisser, 1960; Uhr, 1963) or feature detection (Selfridge, 1959), or the recent debate about whether the facts from which mental imagery is inferred require functional mental images (Kosslyn & Pomerantz, 1977) or a set of propositions (Pylyshyn, 1973), or the controversy over whether retrieval from short-term memory is a serial or a parallel process (Corcoran, 1971; Donahoe & Wessells, 1980; Sternberg, 1969, 1975). Data cannot resolve such debates because components of the various models (rehearsal buffers, storage bins, executive processors, tree structures, and so on) are not constrained by direct observations (of neural structures, for example), and hence, as Anderson (1978) has noted, the models can almost always be modified to take descrepant data into account.

Kosslyn and other "cognitive scientists" are not, for all the trappings, studying cognition; they are studying the effects of extremely complex histories, stimulus materials, and instructions on reaction times and other measures of

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[7] Some physicists would debate the matter. According to Wheeler (1981), for example, quantum mechanics has taught us that "No elementary phenomenon is a phenomenon until it is a registered (observed) phenomenon"; that is, "until is has been brought to a close by an irreversible act of amplification" (pp. 24–25). Different registering devices, furthermore, provide different answers to the same question. According to this view, physics might be construed to be the science of meter readings.

behavior—and then showing how information-processing systems might behave in such ways. This enterprise can shed light on people only if people are information processors, a debatable assertion (Epstein, 1981, 1982b, 1984a).

Skinner and I conducted a modest program of research with a pigeon using reaction time. We first arranged contingencies to produce good waiting behavior and fast key pecks. An auditory ready signal of varying length preceded the onset of a keylight. If a peck occurred within a certain period of time, a feeder operated. The requirement was changed until we reached what appeared to be an asymptotically fast reaction, which was in the range of human simple reaction time (about 200 msec). We then added a discrimination: A peck produced food if the key became transilluminated with green and had no consequence if it became transilluminated with white. With the discrimination well established, the average reaction time to green increased over the simple reaction time. According to Donder's method, the difference in the two times should give us the time for "pure discrimination."

Using similar procedures with humans, Hick (1952) estimated this time to be about 110 msec, and Hyman (1953) found a difference of about 100 msec. The average difference for our pigeon was about the same—120 msec. This tells us that similar requirements produce similar changes in reaction time for humans and at least one pigeon. We add nothing to this fact by claiming that we have measured the time of "pure discrimination" in the pigeon. No doubt there are other correspondences between changes in reaction times in humans and pigeons (cf. Blough, 1977; Hollard & Delius, 1982). But why this is so—or not so—is a matter for the physiologist. Models of the mind can neither account for nor in any way shed light on such a coincidence.

Self-Concept

The concept of a self-concept exemplifies the dilemma of cognitive psychology and has provided an opportunity for demonstrating some advantages of a behavioral approach.[8] The behavior from which it is inferred fits into the fourth category of troublesome phenomena I outlined earlier: It is complex, distinctively human, and not easily traceable to environmental or biological factors. Like language, the behavior that comes under the rubric of "self" is acquired haphazardly over a period of years; in many cases the controlling stimuli are not observable by others.

Like "creativity," "self-concept" is a natural category and hence difficult to define. A wide variety of behavior is said to provide evidence for its existence: body-directed behavior in front of a mirror, pointing to one's picture, gazing at one's picture longer than at another person's picture (for young children, anyway—perhaps, under some circumstances, adults would do the opposite), imitating a videotape of oneself more than a videotape of someone else, and so on. At least these are the measures used by psychologists who study the self-concept (e.g., Amsterdam, 1972; Gallup, 1970; Lewis & Brooks-Gunn, 1979). The verbal behavior said to show "self-knowledge"—describing one's thoughts, feelings, aches and pains, actions, and so on—would also seem to contribute to various notions of "self"; Skinner (e.g., 1945, 1957, 1963, 1974) has offered an account of verbal behavior of this type.

"Self-concept" is one of many psychological terms that are often reified. It is said not only to exist but to grow, in embryonic fashion (Lewis & Brooks-Gunn, 1979). It is, furthermore, mistakenly used to explain behavior that, at best, it only characterizes. Gallup (1979), for example, attributes a lack of behavior said to show self-awareness to a lack of "a sense of identity" and "a sufficiently well-integrated self-concept." That kind of explanation is no explanation at all. Because we can never test for the existence of self-concept independently of the existence of the behaviors said to show it, we can never test the explanation. And no explanation is given for why the self-concept itself may be lacking.

Such a concept obscures the search for more concrete determinants of the behavior. Because it functions grammatically as an explanation, no further explanation is sought. Yet more concrete explanations are usually available.

The rubric of self also mistakenly implies that all the various "self" behaviors have the *same* cause or causes—in the worst case, the cause is said to be the self itself. But, parsimony notwithstanding, it is absurd to think that mirror-directed behavior has the same determinants as an answer to the question "Where does it hurt?" and that a child comes to respond to photographs of its face differently than to photographs of other faces for still the same reasons. Each of the various behaviors said to show the existence of a self-concept demands its own investigation and analysis. A child has many thousands of learning experiences during its first few years of life, and physical maturation has profound effects. A child not only rapidly acquires a wide variety of self-controlled behaviors but many other complex behaviors, as well—verbal and other social behaviors, complex motor skills, and so on. That many "self" behaviors seem to be acquired more or less in unison (Kagan, 1981) is not surprising—after all, *many other* complex behaviors are also acquired during the same period. The first few years of life are a period of rapid acquisition; covariance is—indeed, it *must be*—the rule.

And what of parsimony? A different set of determinants for each of a dozen different "self" behaviors is hardly appealing. The parsimonious solution may prove to lie with a general set of principles of behavior change—one set of functions describing such phenomena as reinforcement, extinction, resurgence, automatic chaining, maturational factors, and so on—that cut across many different "self" behaviors, and, of course, many other behaviors, as well (cf.

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[8] A more detailed analysis of this topic is given by Epstein and Koerner (in press) and Epstein (1985b).

Epstein, 1984c, 1985a). When a child selects its photograph from among a group of photographs, its behavior has the same functional characteristics as the behavior of a pigeon in a "delayed matching-to-sample" task. Similar principles might adequately describe both performances, and, in fact, it would be difficult at this point to rule out the possibility that similar neurophysiological processes underlie each performance. Automatic chaining must operate across many species and across many behaviors, verbal and nonverbal, self and nonself: An organism's own behavior changes its environment in such a way that the probability of subsequent behavior is changed. A student draws an arc on a geometry exam and, in so doing, creates new intersections where the point of the compass can rest. A pigeon pushes a box for the first time toward a suspended banana and, in so doing, sets up box-under-banana, the stimulus in whose presence climbing and pecking the banana had been reinforced in the past; the pigeon stops pushing, climbs, and pecks (see Epstein et al., 1984).

These matters aside, the behaviors that come under the rubric of "self" do seem to have one functional characteristic in common: They all seem to be controlled either by one's own body or by one's own behavior. I use "controlled" here in a technical sense: One's behavior or body is the setting for the "self" behavior; it is the stimulus to which one responds. One responds to one's mirror image—a reflection of one's body—in a special way. One answers the question "Where does it hurt?" by pointing to a location on one's body and the question "How do you feel?" by describing a state of one's body. One answers the question "What did you do last night?" by describing one's behavior.

So "self" behaviors are indeed self behaviors in some sense—they are "self"-controlled. But that does not justify the reification of the "self-concept"; nor does it tell us where these behaviors come from.

Mirrors. When first confronted with a mirror, virtually all birds and mammals, including both human children and adults, react either with indifference or as if they are seeing another organism of their species (Dixon, 1957; Gallup, 1968, 1970; Lewis & Brooks–Gunn, 1979; von Senden, 1960; Wolff, 1943). A variety of fish, birds, and mammals engage in social or aggressive displays or attack their mirror images (Boutan, 1913; Gallup, 1968; Köhler, 1925, Lissman, 1932; Lopez, 1979; Ritter & Benson, 1934, Tinbergen, 1951). Unlike other animals, humans and chimpanzees, after sufficient exposure to a mirror, come to react to their mirror images as images of their own bodies (Gallup, 1979; Lewis & Brooks–Gunn, 1979), though there is at least one contradictory report with chimpanzees (Russell, 1978). This phenomenon—often labeled "self-recognition"—has been studied for at least a century (consider Darwin, 1877).

The modern literature on the topic begins with a paper by Dixon (1957). Human children, according to Dixon, are said to progress through four stages of behavior with respect to their mirror images. In the first few months of life, there is little reaction. Soon the child begins to react to the image as if it were another child, by smiling, playing, touching, vocalizing, and so on. The third stage is one of "testing" or "discovery," characterized by "repetitive activity while observing the mirror image intently, e.g., alternately observing a hand or foot and its mirror image, opening and closing the mouth with deliberation or rising up and down slowly while keeping [the] eyes fixed on the mirror image" (p. 253). Finally, when the child is between 18 and 24 months old, it begins to react to the image as a reflection of its own body.

In the late 1960s Amsterdam (1968, 1972) devised an objective test to determine whether a child had reached the final stage. A mother would smear some rouge on her child's nose and then encourage the child to look at a mirror. If the child touched its nose, it was said to be able to recognize itself. By age 2, most children would do this. Using a mirror to locate a mark on one's body that one cannot see directly is now said to be "the most compelling example of self-directed behavior" (Lewis & Brooks–Gunn, 1979, p. 212).

Gallup (1970) showed that the same effect could be obtained with chimpanzees. Four chimpanzees were exposed to a large mirror for a total of 80 hours over a 10-day period. Social behavior was observed to decline over this period and self-directed behavior (such as grooming) to increase. Then the animals were anesthetized and a red dye painted over an eyebrow bridge and on the top half of an ear. When the animals recovered, they were observed for 30 minutes in the absence of a mirror and for 30 minutes in the presence of a mirror. There were substantially more movements judged to be "mark-directed" in the presence of the mirror (virtually none without the mirror, and an average of 6 per animal with the mirror). Similar tests Gallup arranged with nonhuman primates other than chimpanzees produced negative results. Because he attributed the behavior to a self-concept, he concluded that only man and the great apes (chimpanzees, at least) have this cognitive capacity.

"Self-awareness" in the Pigeon. Epstein, Lanza, and Skinner (1981) provided an alternative account of mark-directed behavior in the mirror test by showing that, after some rather simple training over a period of less than 15 hours, a pigeon, too, could use a mirror to locate a spot on its body which it could not see directly. We first trained the pigeon to peck at blue stick-on dots placed on different parts of its body. Then we added a mirror to the pigeon's chamber and reinforced pecks at blue dots placed on the walls and floor. Finally, we briefly flashed blue dots on the walls or floor when the pigeon could see them only in the mirror. It received food if it turned and pecked the position where a blue dot had been flashed. We then conducted the following test: A blue stick-on dot was placed on the pigeon's breast and a bib placed around its neck in such a way that it prevented the bird from seeing the dot. The pigeon was observed first for 3 minutes in the absence of a mirror and then for 3 minutes in the presence of a mirror. Three subjects were tested. Independent observers scored video tapes for "dot-directed" responses. None were observed when the mirror was absent,

and an average of 10 per bird were observed when it was present—greater than 10 times the rate of mark-directed responses that Gallup (1970) observed (Epstein, in 1985b).

One might conclude from this experiment either that (1) pigeons have a self-concept (few psychologists are likely to go to that extreme), (2) the mirror test is a bad test of self-concept (many will put their money here), or (3) as has already been asserted on other grounds, the self-concept is simply a superfluous scientific category.

These issues aside, we may also have in hand an account of the emergence of such behavior in chimpanzees and children (cf. Epstein, 1981, 1984a), for there is ample evidence that both chimpanzees and children who pass the miror test have already acquired both of the repertories we established in our pigeons: They presumably have touched themselves many times in the places they must touch during the test, and they have had ample opportunities to come under the control of the contingencies of reinforcement which govern mirror use.

Contingencies. Normally, moving toward an object brings it closer and ultimately produces contact with it; one must move in a special way—which most of us never learn perfectly—to produce contact with an object whose reflection we see in a mirror. A mirror thus provides a new set of relationships between one's movements and their consequences—a new set of "contingencies."

These contingencies are rather weak, which is to say that under most circumstances: (1) the reinforcement they provide comes with less effort and more immediately if one simply faces an object directly, and (2) there is no penalty for *not* coming under their control. One would expect, therefore, that only special circumstances would bring an organism's behavior under their control and that the more sensitive the organism's behavior is to its consequences, the more readily the control will be established.

A pigeon, needless to say, would not normally come under the control of these contingencies. We had to supplement them. Attending to an object in the mirror and then finding it in real space not only produced the natural consequence—contact with the object—it also produced food, a powerful, effective reinforcer for a hungry pigeon. The food only supplemented the natural contingency; it did not obliterate or override it. The pigeon's behavior had to be under the control of the correspondence between mirrored and real space in order for food to be delivered.

"Discovery." The period of "testing" or "discovery" that Dixon (1957) described is undoubtedly the period during which a child's behavior comes under the control of the contingencies of reinforcement which govern mirror use. The child slowly learns the correspondence between the locations of parts of its body (and, presumably, of other objects) in real and mirrored space. Unlike the pigeon, the child needs no trainer, but this means only that a child's behavior is so sensitive to its consequences that even occasional exposure to weak contingencies is sufficient for control to be established. Because the contingencies are weak, however, and because the exposure is occasional, it often takes months for control to be established. Presumably, given systematic training, a child or monkey could learn the task even faster than our pigeons.

The same two repertoires probably account for a pigeon's, a chimpanzee's, and a person's success in the mirror test—and hence for some of the behavior often explained by the mythical "self-concept." The only impressive thing about chimpanzees and children is that they can acquire the second repertoire—albeit quite slowly—without explicit training. This is a matter of sensitivity to contingencies. *That* is how man and the great apes differ from other organisms, which should surprise no one.

Conclusions

Praxists have never really met the cognitivists' challenge because in restricting our research to simple behaviors and simple stimuli, we have ignored most of the complex phenomena that they investigate daily. Cognitivists and developmentalists have not found useful answers because they have not asked the right questions. There is little value in trying to determine what a mental structure looks like or how it grows. We achieve a more effective understanding by discovering how the behavior of an organism, both inside and out, is determined by environmental histories and genetic endowments, and ultimately, how changes in behavior are mediated by the body. A model of problem solving is no substitute for a determination of how genes and the environment produce effective behavior. A specification of deep structure or rules of transformation can't tell us where these things come from or how to put them into someone when they seem to be lacking. Attributing insightful behavior to insight is uninformative. Attributing behavior said to show self-awareness to a self-concept tells us nothing.

The time has come for praxists to answer the challenge by bringing complex behavior into the laboratory—in a sense, by giving the freely moving organism a little more freedom to move.

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