

Contingency Adduction of "Symbolic Aggression" by Pigeons

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This study addressed the question: Can novel social behavior arise even though the organism has had no explicit training in that particular social pattern? Seven pigeons were trained individually to peck keys for brief access to food. Four of these birds were also trained to peck two "switching keys" which, at first, raised or lowered the requirements on their own food keys. Later, these switching keys no longer affected an animal's own requirements, but raised or lowered the requirements imposed on a second pigeon working concurrently for food in an adjacent chamber. The second animal was trained only on the food key. In each such pair, the pigeon trained on the switching keys reliably pecked whichever one raised its partner's schedule-requirements. This novel pattern of behavior did not directly benefit the first bird, arose spontaneously as a recombination of previously established nonsocial repertoires, and seemed to be maintained entirely by its effects on the animal in the adjacent chamber.

Parsimonious scientific accounts of complex behavior are problematic, whether describing the behavior of molecules, organisms, ecosystems, or global economies (Gell-Mann, 1994). Behavioral complexity is often exquisitely adapted to an environment which makes up its defining or controlling context, and seems to develop "autonomously" from the outset of the organism's operation in that environment. Accordingly, because of its

obscure origins, one approach is to treat complex behavior as an essential attribute of the organism itself. For example, the earmark of instinctive behavior in animals is its occurrence, on the first instance, in a nearly fully-formed, complex, and immediately adaptive topography under appropriate environmental control. Such behavior is attributed to the genetic and physiological endowment of individual members of the species. Similar nativist accounts have been given for the seemingly effortless acquisition of complex language by human infants (Chomsky, 1980a, 1980b; cf. Palmer, 1985). Another approach is to treat the occurrence of complex behavior as the outcome of the environmental selection history, both over generations (phylogenetic selection) and during the lifespan (ontogenetic selection) of an organism (Donahoe & Palmer, 1994). This biobehavioral approach seeks to understand behavioral complexity as repertoires selected from the combination

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and recombination of previous selections. These combinatorial repertoires in turn become the behavioral substrate for yet other selections, and accordingly, for other levels of complexity (Layng, 1991, 1995).

The present research investigates complex social patterns as untrained recombinations of simpler nonsocial repertoires. Further, the social patterns include the untrained emergence of "symbolic" relations as a result of these recombinations. The experimental issue may be stated in the form of the following question: Given (1) the establishment of specified discriminative and manipulative repertoires in nonsocial contexts, and (2) conditions which are known to induce certain species-typical agonistic patterns when two birds have direct physical access to each other (or which induce other adjunctive patterns when they are alone), but here (3) under conditions which preclude direct physical contact, but provide visual access only, then will a pigeon, with no explicit training to do so, (4) spontaneously emit behavior which is a unique recombination of the repertoires of condition (1), above, in a form of apparatus mediated (or "symbolic") social interaction having effects on a visually accessible conspecific, as in studies on species typical aggression? The latter pattern may be considered "social" to the extent that it is maintained by stimuli produced by the second bird's behavior, and symbolic to the extent that the social pattern involves changes in apparatus mediated stimulus events that derive their social control from the contingent nonsocial history. Finally, it may be considered "instinctually or phylogenetically motivated" to the extent that it occurs under conditions that produce species-typical aggression when a conspecific is present.

If such complex patterns can, indeed, be produced and controlled in laboratory settings, as untrained symbolic social composites of trained nonsocial components, and further, if the composite patterns are maintained by consequences different from those maintaining their trained components, they raise the possibility that other complex patterns in the nonlaboratory ecology may, to

some extent, originate from similar natural recombination to form new functional classes. Further, the untrained origination of new functional classes may have important implications for understanding complex patterns found in everyday life, the psychology clinic, and in the understanding of the development of verbal behavior (Andronis, 1991; Goldiamond, 1974, 1978, 1984; Layng & Andronis, 1984; Skinner, 1957), as well as for those found in nature.

METHOD

Subjects

Seven White Carneaux pigeons (*Columba livia*) served. Four experimentally naive males (P1, P2, P3, and P4) completed all phases of training, and were designated as "referent birds." One female (T1) and two other males (T2 and T3), with previous experimental histories unrelated to the present study, were given only the first phase of training, and were designated as "target animals." All subjects lived in individual home cages under a 12 hr light/dark cycle. They obtained their food almost exclusively through contingencies arranged during daily experimental sessions, but had constant access to grit and fresh water in their home cages. On days when sessions were not conducted, the subjects received just enough mixed grain in their home cages to maintain them at approximately 85 percent (+5 percent) their individual *ad lib* weights.

Apparatus

The experimental space is illustrated in Figure 1. It consisted of a large rectangular space, 130 cm wide by 68 cm deep by 43 cm high, divided by a pair of clear acrylic panels arranged 20 cm apart at the front wall but angled to meet at the center of the rear wall. The transparent acrylic partition allowed a clear view of each chamber from the other. The chambers were independently lighted by two banks of incandescent houselights (red, green, and either white or yellow), located at the rear (directly opposite the "food key") above the clear acrylic ceiling.

The front wall of each chamber had a

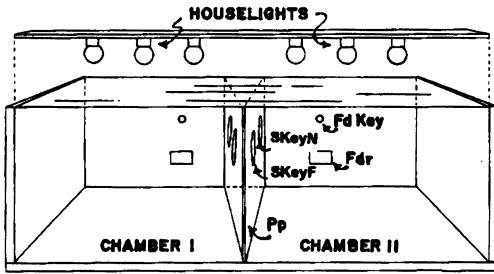


Fig. 1. Experimental chambers viewed from the rear. A clear Plexiglas partition (Pp) separated the chambers. A subject in either chamber obtained brief access to grain by pecking a food key (FdKey) located on the front wall directly above an automated feeder (Fdr). Different schedules of reinforcement programed on the food key were correlated with red, green, and white (or yellow) houselights, located overhead at the rear of each chamber. Under social conditions, the Switching Keys (SKeyN, SKeyF) of one chamber controlled the food key schedules and correlated houselight colors in the opposite chamber.

standard pigeon key, designated as the "food key," with an automated feeder located directly beneath it. In addition, the acrylic partition-wall of each chamber had two large, transparent piezoelectric keys which were designated as "switching keys" (SKeys); these keys were 10 cm in diameter, mounted side-by-side, and required forces of only about 0.005 N to register pecks. All keys were located with their centers 26.7 cm from the floor. A white-noise generator and ventilating fan masked extraneous sounds. All experimental events were controlled and counted by a microcomputer, with keypecks and feeder operations graphed by on-line cumulative recorders. Subjects were observed during all sessions by means of a video-monitor located in another room. Some sessions were videotaped for later viewing.

Procedure

Training: establishing component repertoires. Each subject was individually trained in one of the two adjoining chambers, with the opposite chamber empty. Training sessions lasted one hour apiece.

Component 1. Discriminative control over work requirements by houselight colors.

First, all seven subjects were trained by successive approximations to peck their food keys for brief access to grain from

their feeders. Over the next 10 sessions, work requirements programed on the food keys were gradually increased from one peck per food delivery (i.e., a Fixed-Ratio 1, or FR-1) to fifty pecks (FR-50), under white houselights. Then, the FR-50 under white houselights alternated within sessions pseudorandomly with two other schedules, a smaller FR-1 under red houselights and a larger FR-75 under green houselights. All seven subjects came under appropriate discriminative control of this multiple schedule (MULT FR-1; FR-50; FR-75) in just three sessions.

Component 2. Pecking the SKeys, and changing own work requirements and houselight colors.

Only the four referent birds (P1, P2, P3, and P4) completed the next phases of training. The intermediate work requirement (FR-50) was programed on the food key from the start of each session. This requirement recurred after every feeder operation, and remained in effect except when a subject pecked its SKeys. Each referent bird was now trained by successive approximations to peck the SKeys. Pecking on the SKeys was reinforced only by a reduction of the bird's food key requirements, and never directly by access to food. The bird was trained first to peck SKeyF (the switching key farthest from the food key), and then in a like manner to peck SKeyN (the switching key nearest the food key). Whenever one SKey reduced the food key work requirement, the other concurrently raised it. Next, the SKeys contingencies were reversed every 15 minutes within sessions, to minimize establishment of position preferences. At the same time, the lowest work requirement on the food key, always correlated with red houselights, increased gradually from FR-1 to FR-20 over successive sessions. Finally, work requirements were imposed on the SKeys themselves, so that a bird eventually had to peck a SKey ten times to change the food key schedule and corresponding houselight color. All of the referent birds completed this second phase of training in 20 to 29 days, reliably pecking whichever

SKey lowered their own food key requirements on every trial in the session.

Component 3. Transferring previously acquired behaviors to adjacent chamber, extinguishing SKey control over own work requirements.

In the following experiments, procedural attention was directed toward maintenance of pecks on the SKeys by events in the adjacent chamber. Accordingly, the birds were now switched to the opposite chambers from those in which they were originally trained, and the equipment was altered so that pecks by a referent bird on its own SKeys changed the food key schedule and correlated houselights in the adjacent chamber, but did not affect conditions in the subject's own chamber. Each referent bird was run under these conditions for five days with the adjacent chamber empty; the schedule programed on its food key was now a constant FR-50 under white houselights. At first, the subjects pecked the SKeys in long extinction-like runs, but stopped pecking the SKeys altogether by the fourth or fifth sessions and pecked only their food keys in the patterns typically controlled by an FR schedule.

Social conditions. Referent birds and target animals were now paired and run simultaneously, one bird in each of the two adjacent chambers: P1 and P3 served consecutively in Chamber I under like sequences of conditions, with T2 in the adjacent chamber during their respective sessions; similarly, P2 and P4 served consecutively in Chamber II under like experimental sequences, with T1 in the adjacent chamber during their sessions. As in the last phase of training, pecks by a referent bird on its SKeys did not affect conditions in its own chamber, but instead changed the work requirements for food and house-light colors in the adjacent chamber (which now held a target animal).

Social Condition 1. Arrangements which do not typically result in aggressive behavior.

Both birds in a pair now had the same FR-50 schedules of reinforcement programed on their food keys. For the referent

bird, this requirement remained constant throughout each session, but the target animal's work requirement increased (to FR-100) or decreased (to FR-10) whenever the referent bird pecked its own SKeys. Concurrently, the target animals had access to identical but inactive SKeys which, when pecked, registered and counted pecks but had no other programed effects. After 35 sessions, only one of the referent birds (P4) ever pecked its SKeys, and then only a few times a session. The other referent birds (P1, P2, and P3) never pecked them; neither did the target animals.

Social Condition 2. Arrangements which make aggressive behavior more likely.

The next experiment examined whether referent birds would peck their SKeys when an Fixed-Interval (FI) schedule of reinforcement was now programed on the food keys, rather than FR schedules described above. In an FI schedule, the bird need only peck its key once to obtain food, but must wait until a timer (in this case, set to a 40-sec interval) has timed down. Pecks occurring before the 40-sec interval has elapsed have no programed effects, and a new timer interval automatically begins immediately after each food delivery ends. Under this arrangement, animals have been observed to engage in behaviors, often referred to as "schedule-induced," during interreinforcement intervals without sacrificing food deliveries (Falk, 1971, 1977; Roper, 1981; Staddon, 1977; Wetherington, 1982). Such induced behaviors have included "aggression" when a conspecific is present (Cherek & Heistad, 1971; Dove, Rashotte, & Katz, 1974; Looney, Cohen, & Yoburn, 1976; Ulrich, Dulaney, Arnett, & Mueller, 1973).

A recycling FI 40-sec schedule of reinforcement (with 3-sec feeder operations) was thus programed on the food keys of both chambers, accompanied now by yellow houselights. As before, the food key requirement of the referent bird was completely independent of events in the adjacent chamber; on the other hand, the target animal's food key requirement depended in large part on events in the referent bird's

Table 1
Experimental control conditions, procedures, and their rationales.

Condition	Procedure	Rationale for Procedure
FG	Described in text. Referent birds' Food Key: FI-40 & yellow houselight; single peck to SKeyF: FR-100 in adjacent chamber & green houselight; single peck to SKeyN: FR-10 in adjacent chamber & red houselight. Referent birds' pecks on SKeys had no effect on own FI-40. Target birds' Food Key: FI-40 & yellow houselight unless changed by Referent birds.	The baseline condition which alternated repeatedly with other control conditions.
O	Identical to F _G , except that the referent bird now served alone, without a target animal in the adjacent chamber.	Condition O was established to distinguish whether pecks on the switching keys were indeed related to the presence of a target animal, or were maintained merely by changes of houselight colors in the adjacent chamber.
N _G	SKeyN and SKeyF effects reversed; single peck to SKeyF: FR-10 in adjacent chamber & red houselight; single peck to SKeyN: FR-100 in adjacent chamber & green houselight; in all other respects identical to F _G .	Served as a control for possible position preferences by the referent birds.
2F _G , 3F _G , 5F _G	Referent birds P2 and P4 had to complete FR-2, FR-3, and FR-5 requirements, respectively, on the Skeys to change the food-key schedule & houselights of their common target animal; in all other respects identical to F _G .	Assessed whether any reinforcing consequences of pecking the switching keys were sufficiently potent to sustain higher than baseline rates of pecking on those keys.
PROBE N _R	Pair P4 (Referent bird) and T3 (Target bird) served alone. Single peck (by P4) to SKeyN: FR-100 in adjacent chamber & the red houselights; single peck to SKeyF: FR-10 in adjacent chamber & green houselights; in all other respects identical to F _G .	Assessed the extent to which a referent bird's switching key preferences might be governed exclusively by changes of houselight colors in the adjacent chamber, by corresponding changes in the target animal's behavior, or by-products of that behavior (i.e., feeder operation).
PROBE F _R	Single peck to SKeyN: FR-10 in adjacent chamber & the green houselights; single peck to SKeyF: FR-100 in adjacent chamber & red houselights; in all other respects identical to F _G .	Assessed whether a reversal of SKey position effects would bring the referent bird's behavior under the control of changes in the target animal's behavior, or by-products of that behavior (i.e., feeder operation).
PROBE m	P4 was subjected to a single 80-min session where the schedule programmed on the Food Key was pseudorandomly varied between an FI-40 & yellow houselight, FR-10 & green houselight, or FR-100 & red houselight. Pigeon T3 was not in the adjacent chamber during Condition m.	Assessed the role of contingent history on P4's SKey preference when Probe Conditions N _R and F _R were reintroduced.

chamber. Operations of referent bird's own feeder reset a new FI-40 sec requirement in both chambers, regardless of the schedule then in effect for the target animal; completion of any schedule requirement by the target animal reset only its own schedule to a new FI-40 sec requirement. All other arrangements remained the same. An asymmetrical relationship was created in which the referent bird, by pecking an SKey, could raise or lower the rate of food acquisition by the target animal, but the target animal could not alter the referent bird's rates of obtaining food, hence avoiding a competitive arrangement. This arrangement, designated Condition F_G , served as the baseline which alternated repeatedly with other control conditions.

All social conditions were designated N or F, depending upon which SKey pecks (Near or Far) imposed the *high* work requirement on the target animal, with subscripts G or R indicating that this high requirement was correlated with either green or red houselights in the given condition. For referent bird P4, a new target animal (T3), trained exactly like the others, was provided under Condition F_G in Sessions 98-107. Table 1 describes all experimental control conditions, procedures, and the rationale for each.

RESULTS

The results obtained from all four referent birds were essentially the same for comparable conditions. Figures 2 and 3 show exact sequences of experimental conditions, numbers of sessions under each condition, and individual referent birds' rates of pecking on the SKeys when an FI 40-sec schedule of food reinforcement was programed concurrently on the food keys.

Within about 10 sessions, all four referent birds pecked their food keys in the temporally scalloped patterns typically maintained by FI schedules, although at different overall rates. All the referent birds consistently obtained food deliveries at the maximum rate possible under the present food key schedule (around 1.33/min) throughout the experiment, virtually without variation.

Under baseline Condition F_G , all four ref-

erent birds preferentially pecked SKeyF. Across most sessions under this condition, rates of pecking on SKeyF were about an order of magnitude higher than corresponding rates on SKeyN. Referent bird P4, who was separately paired under baseline Condition F_G with two different target animals (T1 and T3), clearly preferred SKeyF to SKeyN regardless of the target animal present.

This clear preference reversed under Condition N_G . Subjects P1, P2, and P4 each underwent two such reversals, and P3 underwent three. In each case, there was a change to preferential pecking on SKeyN under Condition N_G , and back again to SKeyF when the birds were returned to baseline. Therefore, the observed patterns of preference, for pecking SKeyF under baseline Condition F_G , and, conversely, for pecking SKeyN under Condition N_G , was not governed simply by the positions of the preferred keys. Instead, the referent birds seemed to "track" whichever SKey at the moment raised the work requirements in the adjacent chambers.

During sessions when they were run without target animals (Condition O), the referent birds rarely pecked either SKey. Subjects sometimes flapped their wings violently while facing the empty adjacent chamber; hence, nearly all events on the SKeys during Condition O were generated exclusively by such accidental contacts of their flapping wings with the SKeys. Nevertheless, events on the SKeys decreased by about an order of magnitude whenever the adjacent chamber was empty. As soon as target animals were restored to the adjacent chambers in subsequent sessions, the referent birds immediately resumed pecking the SKeys, again preferring that SKey which raised target animals' work requirements. Thus, the presence of a target animal in the adjacent chamber appeared critical to maintaining the referent birds' pecks on the SKeys.

To assess the potency of change in the adjacent chamber as a reinforcer for pecking the SKeys, birds P2 and P4 were subjected to Conditions $2F_G$, $3F_G$, and $5F_G$. Rates of pecking on SKeyF increased such

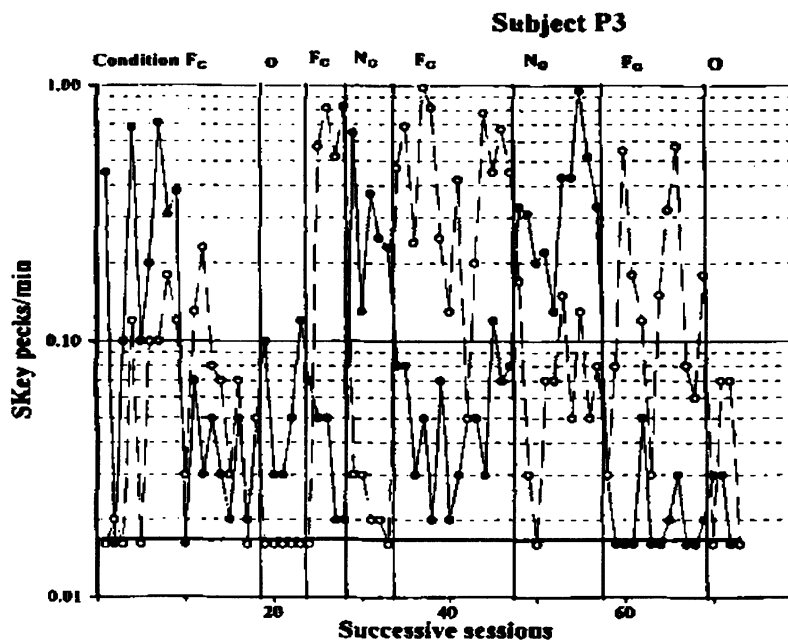
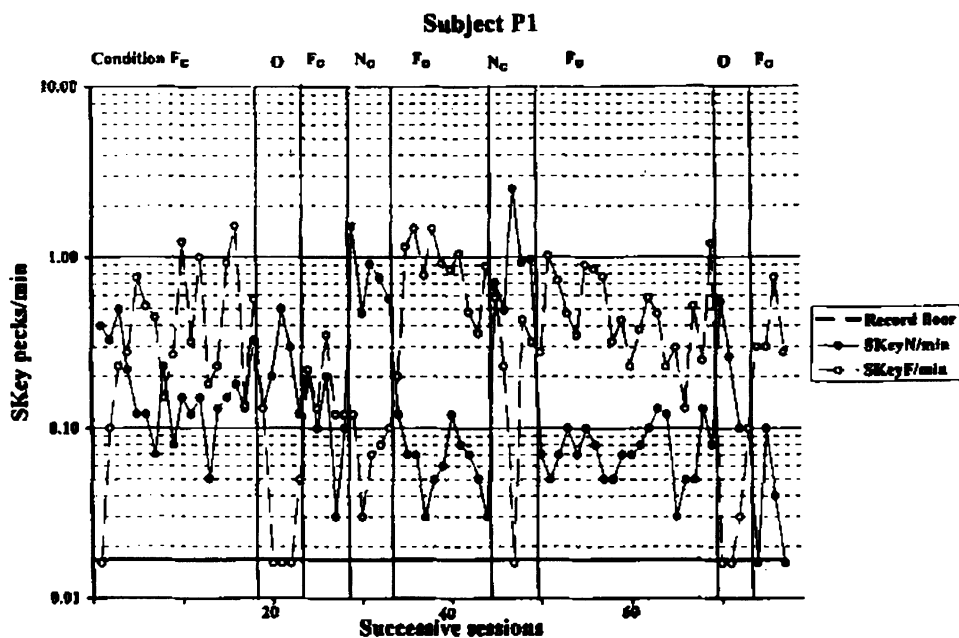


Fig. 2. Rates of pecking by referent birds P1 and P3 on the Switching Keys during successive sessions under each condition. In Conditions F_c and O , Switching Key N (SKKeyN, closed circles, ●) controlled both the red lights and low FR requirement on the food key of the adjacent chamber, and Switching Key F (SKKeyF, open circles, ○) controlled the green lights and high FR requirement on the food key of the adjacent chamber. During Condition N_c , the effects of pecking SKKeyN and SKKeyF were reversed. Target animal T2 was present in the adjacent chamber under all conditions except O , when that chamber was empty.

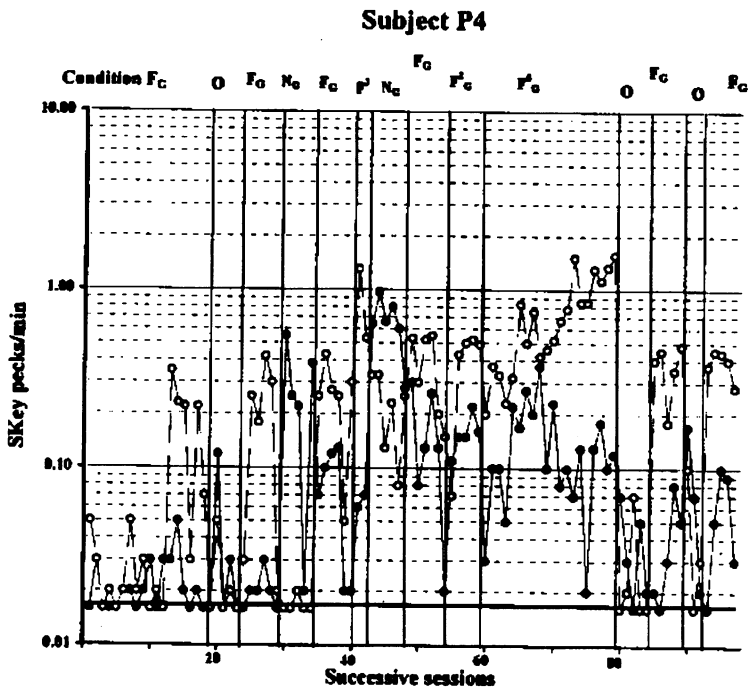
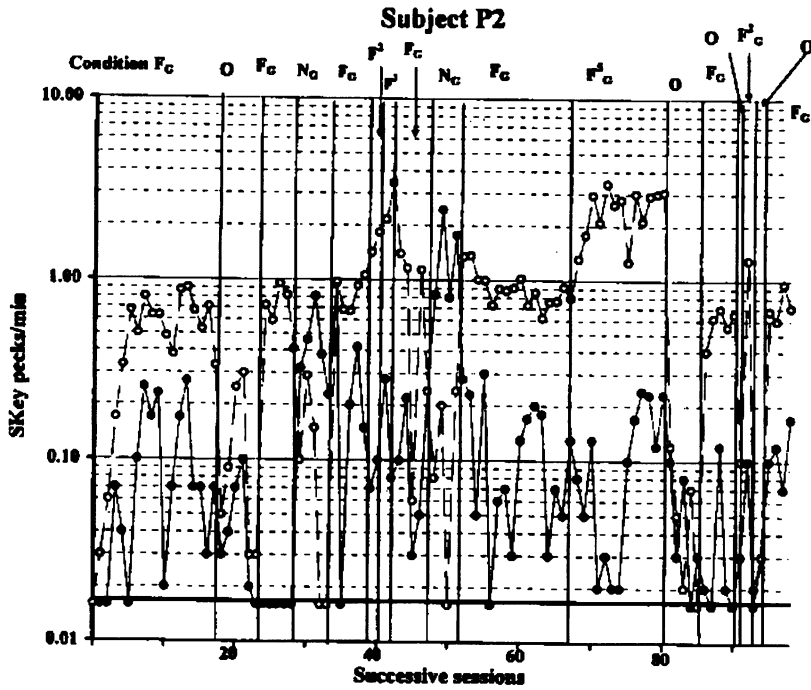


Fig. 3. Rates of pecking by referent birds P2 and P4 on the Switching Keys during successive sessions under each condition. In Conditions F_c , O, and $2F_c$, $3F_c$, and $5F_c$, Switching Key N (SKeyN) controlled both the red lights and low FR requirement on the food key of the adjacent chamber, and Switching Key F (SKeyF) controlled the green lights and high FR requirement on the food key of the adjacent chamber. During Condition N_c , the effects of pecking SKeyN and SKeyF were reversed. Target animal T1 was present in the adjacent chamber under all conditions except O, when that chamber was empty. In Conditions $2F_c$, $3F_c$, and $5F_c$, FR-2, FR-3, and FR-5 requirements, respectively, were imposed on both Switching keys, which were FR-1 during all other conditions.

that the referent birds imposed unfavorable conditions on their target animals about as often under these conditions as when single pecks had such effects under baseline Condition F_C . Rates on SKeyN remained relatively unchanged. These results indicate that changes in the adjacent chamber were sufficiently potent to maintain relatively high rates of pecking SKeyF by the referent birds.

Pecks on the SKeys had at least four discriminable effects, which together or alone might have maintained the referent birds' SKey preferences in the presence of target animals: 1) change of houselight color in the adjacent chamber, from yellow to that correlated with a high work requirement for the target animal; 2) corresponding changes in the target animal's schedule-controlled patterns of pecking on the food key; 3) agonistic behavior by the target animal when its work requirements increased, and 4) changes in the rate of feeder operations in the target animal's chamber. Therefore, the question remained: What aspect(s) of this complex stimulus-change produced by pecks on the SKeys actually maintained a referent bird's preference even when an increased work requirement was placed on the SKeys? The final set of probe conditions, involving only referent bird P4 and target animal T3, attempted to address these issues.

Probe conditions, N_R and F_R , reversed the previous procedural associations between food key schedules and houselight colors. The red houselight accompanied an FR-100, the green houselight accompanied an FR-10. Thus, if the referent bird's preference were governed alone by changes of houselight colors in the adjacent chamber, then the referent bird would continue pecking whichever SKey controlled that chamber's green houselights, as before. If, instead, preference for a given SKey were governed by changes in the target animal's behavior, particularly those associated with high work requirements, then the referent bird should now begin pecking whichever SKey which was followed by the appropriate changes in the target animal's behavior under red house-

lights rather than green. Referent bird P4 and target animal T3 were used in the probe.

Figure 4 shows the exact sequence of conditions, numbers of sessions, and the results obtained with referent bird P4 under the probe conditions. When Condition N_R was first imposed, referent bird P4's preference for pecking SKeyF was apparently maintained by the resulting change to green houselights in the adjacent chamber, and not by related changes in the behavior of the target animal or its rate of feeder operations. Under Condition F_R , however, pecks on SKeyF seemed to continue as a function of mere key position. Then, when Condition N_R was subsequently reinstated, P4 pecked both SKeys alternately within the same trials, with only slight preference for SKeyF. These results, taken together, suggest that P4's original preference for pecking SKeyF was governed largely by the contingency between SKey pecks and onset of green houselights in the adjacent chamber. Nevertheless, this bird's previously strong preference was partially abolished under Condition F_R ; hence, the altered relation between houselight colors and associated behavior by the target animal under Conditions N_R and F_R appeared to have had at least disruptive effects on P4's preference.

In Condition m , bird P4 was subjected alone for one 80-min session to the same three alternating work requirements on its own food key that were in effect for its chamber-mate, T3. This was done to ascertain the extent to which P4's SKey preference actually depended upon the subject's own prior exposure to the specific work requirements correlated with red and green houselights. Bird T3 was absent during this session.

Condition N_R was now reinstated, with T3 restored to the adjacent chamber. During the first two such sessions, bird P4 now pecked SKeyN at about twice the rates on SKeyF. Over the 9 subsequent sessions under Condition N_R , P4 pecked SKeyN at rates comparable to those on SKeyF under the original baseline; at the

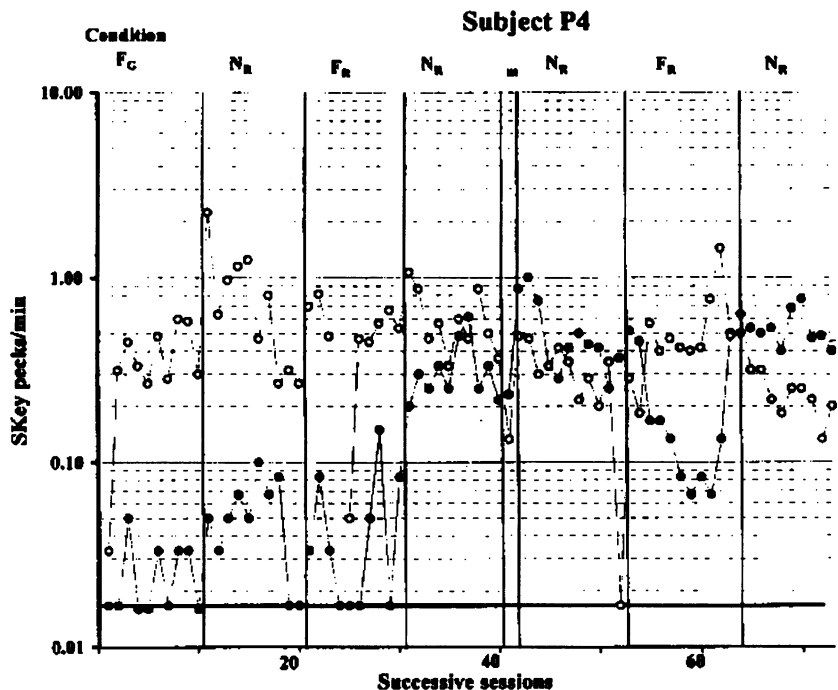


Fig. 4. Rates of pecking by referent bird P4 on Switching Key A (closed circles, ●) and Switching Key B (open circles, ○) during successive sessions under baseline Condition B_C, and probe Conditions N_R, F_R and m. The bird's Switching keys now controlled FR-100 + red and FR-10 + green in the target animal's chamber, a reversal of previous correlations between houselight colors and schedule requirements. For a single session under Condition m, referent bird P4 itself was subjected individually to a MULT schedule with the same correlations between houselights and schedule requirements that held for the target animal under Conditions N_R and F_R.

same time, pecking on SKeyF declined gradually to a low rate by Session 43. This was the first clear instance, under any social condition, where a referent bird preferred SKeyN while that key controlled the red houselights in the target animal's chamber.

Subsequently, Condition F_R was reinstated, again reversing the positions of the referent bird's SKeys with respect to their effects in the adjacent chamber. In the first session, P4 continued slightly to prefer pecking SKeyN, but thereafter reversed dramatically, with rates on SKeyN falling progressively across these sessions, and rates on SKeyF rising eventually to 1.39/min. Finally, when Condition N_R was reinstated, the subject now preferentially pecked SKeyN again, at a relatively stable rate of about .50/min, while rates on SKeyF again fell steadily. These results indicate that P4 now preferred whichever SKey controlled the red houselights, and

high work requirement, of the target animal.

Taken together, the probe conditions indicate that neither the target animals' food-related behavior nor its rate of feeder operation alone were sufficient to produce a reversal of color preference by the referent bird. Moreover, examination of rates of food acquisition by the target animal and corresponding rates of SKey pecking by the referent bird revealed no correlation between these sets of events. That is, the referent bird did not appear to be pecking the preferred SKey more or less frequently because of the rate of feeder operations in the adjacent chamber. Because this systematic reversal of original preference from green to red houselights occurred only after imposition of Condition m, when P4 was itself exposed to the new correlations between houselight colors and food key schedules, it seems that P4's SKey preference was in fact governed by complex historical relations between SKey contingen-

cies and stimuli related to behavior of the target animal. Stated otherwise, the symbolic use of these stimuli was dependent upon a specific nonsocial individual history that involved coming in contact with the aversive conditions correlated with the stimulus presentation.

This final alternative is plausible and parsimonious. Namely, when the pigeons in the present study worked for food under conditions known to induce aggression, but were not given the opportunity to engage in conventional or species-typical aggressive behavior, previously trained nonsocial repertoires recurred and recombined in a way that eventually met the functional requirements of new, complex, apparatus-mediated (symbolic) social contingencies. These historical components included escaping from a stimulus (house-lights that accompanied a high work requirement) that the birds would later *work to produce* when the stimulus occurred in an adjacent chamber with a conspecific present, and not in its own chamber.

DISCUSSION

The apparently spontaneous occurrence of this new untrained class of social behavior is an attribute shared, in part, with other behaviors commonly considered to be "innate," like the various adjunctive or schedule-induced behaviors (Falk, 1971, 1977, 1981; Roper, 1981; Staddon, 1977; Wetherington, 1982), including aggression (Cherek & Heistad, 1971; Cherek, Thompson, & Heistad, 1973; Cole & Parker, 1971; Looney, Cohen, & Yoburn, 1976), which typically occur under procedural arrangements similar to those of the present study. Here, however, repertoires established in one contingency context

later met the formal requirements of entirely new contingencies, and thereafter comprised a wholly different functional class of behavior, a process we call "contingency adduction" (Andronis, 1983; Layng & Andronis, 1984). The term describes a terminal contingency drawing simpler constituent repertoires out of their separate formative classes into a single new, and often more complex functional class. This is consistent with ethological formulations of how so-called "learning variables" might contribute to the expression and refinement of innate patterns of behavior, or what has been called the "intercalation of learning with instinct" (see Lorenz, 1967, 1981; Schiller, 1957). Thus, the origins of the component repertoires may involve ontogenetic or phylogenetic contingencies (or both) (Layng, 1991). This observation may have important implications for resolving questions raised in the debate over innate vs. learned origins for language and other complex human repertoires.

This route to establishing novel classes of behavior, although similar, can be distinguished from what Epstein (1981, 1987), and Epstein et al. (1984) described as the interconnecting of repertoires. In the latter, several topographically different repertoires, established separately but maintained by the same consequences, subsequently interconnect into an automatic chain of behaviors maintained again by the same consequences as those occurring during establishment. On the other hand, the relation observed in the present study involved topographically and functionally different component repertoires combining into an entirely new functional class; that is, a composite repertoire maintained by consequences different from those which established the individual component repertoires. Further, it involved preference for a stimulus from which the birds had in the past worked to escape, an outcome not well described by the simple inter-connecting of behaviors reinforced in the past, nor

¹ Recall that pecking the SKeys did not affect the referent bird's own schedule requirements for food reinforcement, nor was it maintained adventitiously by food reinforcement when the referent bird completed the work requirements on its food key. As a procedural safeguard against this possibility a 10-sec changeover delay was imposed between any pecks by a referent bird on its switching keys and the next reinforced peck on its food key. This arrangement proved unnecessary, though, because the referent bird never pecked a switching key within ten seconds of its next opportunity for reinforcement programed on the food key.

² Stated differently, the terminal contingency makes their occurrence more likely in the absence of behaviors, or other contingency elements, that meet the contingency requirement (Andronis, 1983, 1991; Johnson & Layng, 1992; Layng, 1995).

simply by the resurgence (Epstein, 1983, 1985; Epstein & Skinner, 1980) of previously reinforced behavior.

Human aggressive behavior often involves a variety of learned motor and discriminative repertoires which, under other circumstances, might not be considered to be aggressive or even social. For example, one important form of human aggression, called "sabotage," is named after the wooden shoes ("sabots") worn and sometimes thrown into factory machinery by European peasants during the Industrial Revolution, causing serious damage, halting production, and forcing factory owners to make costly repairs. Often, verbal behavior may be aggressive in this way, with targeted individuals suffering such costs as damage to their prestige, adverse changes in other important social relations, or increases in certain response requirements. The familiar clinical metaphor of one person's "sabotaging" another's psychiatric treatment is direct acknowledgment of such a relation between verbal and nonverbal aggression. The present study suggests that these latter forms of aggression need not be considered uniquely human, that they may be studied effectively by laboratory approaches directed heretofore primarily at the behavior of non-human subjects, and that, given the appropriate individual histories, pigeons will indeed engage in such complex patterns under social contingencies established in the laboratory. As noted, corresponding behaviors in nonlaboratory settings may, to some extent, derive from similar "natural" histories of contingencies.

The kind of relations reported here may be more common than has been recognized in the past, and may provide, through contingency adduction, a selectionist account of the origins of at least some forms of behavioral complexity. Several important human social repertoires, particularly verbal behavior and affective displays, have been widely considered to have largely innate origins, and have been attributed to structural endowments of individuals. This investigation may provide a parsimonious selectionist alternative to traditional struc-

turalist accounts, may point the way toward new experimental models of symptom choice, and perhaps suggest some origins of human psychopathologies, particularly those involving novel or bizarre forms of verbal behavior (Layng & Andronis, 1984; Layng, 1994).

REFERENCES

- Andronis, P. T. (1983). *Symbolic aggression by pigeons: Contingency coadduction*. Dissertation: The University of Chicago, Chicago, IL (UMI Dissertation Services).
- Andronis, P. T. (1991). Rule-governance: Enough to make a term mean. In L. J. Hayes & P. N. Chase (Eds.), *Dialogues on verbal behavior* (pp. 226-235). Reno, NV: Context Press.
- Cherek, D. R., & Heistad, G. T. (1971). Fixed-interval-induced aggression. *Psychonomic Science*, 25, 7-8.
- Cherek, D. R., Thompson, T., & Heistad, G. T. (1973). Responding maintained by the opportunity to attack during an interval food reinforcement schedule. *Journal of the Experimental Analysis of Behavior*, 19, 113-124.
- Chomsky, N. (1980a). Initial states and steady states. In M. Piatelli-Palmerini (Ed.), *Language and learning: The debate between Jean Peaget and Noam Chomsky* (pp. 107-130). Cambridge, MA: Harvard University Press.
- Chomsky, N. (1980b). Rules and representations. *Behavioral and Brain Sciences*, 3, 1-61.
- Cole, J. M., & Parker, B. K. (1971). Schedule-induced aggression: Access to an attackable target bird as a positive reinforcer. *Psychonomic Science*, 22, 33-35.
- Donahoe, J., & Palmer, D. C. (1994). *Learning and complex behavior*, New York: Allyn & Bacon.
- Dove, D. L., Rashotte, M. E., & Katz, H. N. (1974). Development and maintenance of attack in pigeons during variable interval reinforcement of keypecking. *Journal of the Experimental Analysis of Behavior*, 21, 563-569.
- Epstein, R. (1981). On pigeons and people: A preliminary look at the Columban Simulation Project. *The Behavior Analyst*, 4, 43-56.
- Epstein, R. (1983). Resurgence of a previously reinforced behavior during extinction. *Behaviour Analysis Letters*, 3, 391-397.
- Epstein, R. (1985). Extinction induced resurgence: Preliminary investigations and possible applications. *Psychological Record*, 35, 143-153.
- Epstein, R. (1987). The spontaneous interconnection of four repertoires of behavior in a pigeon (Columba livia). *Journal of Comparative Psychology*, 101, 197-201.
- Epstein, R., Kirschnit, C. E., Lanza, R. P., & Rubin, L. C. (1984). "Insight" in the pigeon: Antecedents and determinants of an intelligent performance. *Nature*, 308, 61-62.
- Epstein, R., & Skinner, B. F. (1980). Resurgence of responding after the cessation of response-independent reinforcement. *Proceedings of the National Academy of Sciences, USA*, 77, 6251-6253.
- Falk, J. L. (1971). The nature and determinants of adjunctive behavior. *Physiology & Behavior*, 6, 577-588.

- Falk, J. L. (1977). The origins and function of adjunctive behavior. *Animal Learning and Behavior*, 5, 325-335.
- Flory, R. K., & Ellis, B. B. (1973). Schedule-induced aggression against a slide-image target. *Bulletin of the Psychonomic Society*, 2, 287-290.
- Frederiksen, L. W., & Peterson, G. L. (1977). Schedule-induced aggression in humans and animals: A comparative parametric review. *Aggressive Behavior*, 3, 57-75.
- Gell-Mann, M. (1994). *The quark and the jaguar*, New York: W. H. Freeman & Co.
- Goldiamond, I. (1974). Toward a constructional approach to social problems: Ethical and constitutional issues raised by applied behavior analysis. *Behaviorism*, 2, 1-84.
- Goldiamond, I. (1978). The professional as double-agent. *Journal of Applied Behavior Analysis*, 11, 178-184.
- Goldiamond, I. (1984). Training parents and ethicists in nonlinear behavior analysis. In R. F. Dangel & R. A. Polster (Eds.), *Parent training: Foundations of research and practice* (pp. 504-546). New York, Guilford Press.
- Hutchinson, R. R., Azrin, N. H., & Hunt, G. M. (1968). Attack produced by intermittent reinforcement of a concurrent operant. *Journal of the Experimental Analysis of Behavior*, 11, 489-496.
- Johnson, K. R., & Layng, T. V. (1992). Breaking the structuralist barrier: Literacy and numeracy with fluency. *American Psychologist*, 47, 1475-1490.
- Layng, T. V. J. (1991). A selectionist approach to verbal behavior: Sources of variation. In L. J. Hayes & P. N. Chase (Eds.), *Dialogues on verbal behavior* (pp. 146-150). Reno, NV: Context Press.
- Layng, T. V. J. (1994). *Programmed head-banging by pigeons: Cessation and return*. Dissertation: The University of Chicago, Chicago, IL (UMI Dissertation Services).
- Layng, T. V. J., & Andronis, P. T. (1984). Toward a functional approach to delusional speech and hallucinatory behavior. *The Behavior Analyst*, 7, 139-156.
- Knutson, J. F. (1973). Aggression as a manipulable behavior. In J. F. Knutson (Ed.), *The control of aggression: implications from basic research*. Chicago: Aldine Publishing Co.
- Looney, T. A., & Cohen, P. S. (1982). Aggression induced by intermittent positive reinforcement. *Biobehavioral Reviews*, 6, 15-37.
- Looney, T. A., & Cohen, P. S., & Yoburn, B. C. (1976). Variables affecting the establishment of schedule-induced attack on pictorial targets in White King pigeons. *Journal of the Experimental Analysis of Behavior*, 26, 349-360.
- Lorenz, K. (1967). *Evolution and the modification of behavior*. Chicago, IL: The University of Chicago Press, First Phoenix Edition.
- Lorenz, K. (1981). *The foundations of ethology: Principle discoveries on animal behavior*. New York: Simon and Schuster.
- Palmer, D. C. (1985). Chomsky's nativism: A critical review. In P. N. Chase & L. J. Parrott (Eds.), *Psychological aspects of language* (pp. 44-60). Springfield, IL: Charles C. Thomas, Publisher, .
- Roper, T. J. (1981). What is meant by the term, "Schedule-induced," and how general is schedule-induction? *Animal Learning and Behavior*, 9, 423-430.
- Schiller, P. H. (1957). Innate motor action as a basis of learning: Manipulative patterns in the chimpanzee. In C. H. Schiller (Ed.), *Instinctive behavior: The development of a modern concept* (pp. 264-287). New York: International Universities Press, Inc.
- Skinner, B. F. (1957). *Verbal behavior*. New York: Appleton-Century-Crofts.
- Staddon, J. E. R. (1977). Schedule-induced behavior. In W. Honig & J. E. R. Staddon (Eds.), *Handbook of operant behavior* (pp. 125-152). New York, Appleton-Century-Crofts.
- Thompson, T., (1964). Visual reinforcement in fighting cocks. *Journal of the Experimental Analysis of Behavior*, 7, 45-49.
- Ulrich, R. E., Dulaney, S., Arnett, M., & Mueller, K. (1973). An experimental analysis of nonhuman and human aggression. In Knutson, J. F. (Ed.), *The control of aggression: Implications from basic research*. Chicago: Aldine Publishing Co.
- Wetherington, C. L. (1982). Is adjunctive behavior a third class of behavior? *Neuroscience and Biobehavioral Reviews*, 6, 329-350.