SHORT REPORT

Scratch and Match: Pigeons Learn Matching and Oddity With Gravel Stimuli

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Two groups of 4 pigeons learned either matching-to-sample or oddity-from-sample by digging in white and black gravel for buried grain. Learning occurred as early as Trial 11, and acquisition was accelerated by as much as 100-fold compared with learning in traditional key-peck environments. Control experiments showed that performance was not controlled by cues other than the gravel stimuli and was not due to distributed practice effects of 8 trials per day and longer intertrial intervals.

Comparative cognition has recently received considerable attention. Animals have demonstrated cognitive abilities far beyond what researchers thought they were capable only a few years ago. One development fostering this interest in comparative cognition has been instances of researchers capitalizing upon natural predispositions of some animals and adapting them to laboratory study. Examples of these adaptations of natural behaviors include seed caching and recovery by chickadees and nutcrackers (e.g., Kamil & Balda, 1985; Shettleworth, 1985), digging at landmarks by pigeons (e.g., Cheng, 1988), and grain-and-gravel search by pigeons (e.g., Bond, 1983). Learning in these tasks is rapid, if not instantaneous, and in some cases the cognitive abilities are remarkable. One shortcoming of these tasks is that they often do not make contact with previous tasks used in the study of avian learning and cognition (e.g., matching-to-sample) or human cognition and memory (e.g., visual recognition memory). Many of these other tasks are relational tasks in which one stimulus is related to another stimulus, and cognition in relational tasks may involve different brain structures (at least in primates) than tasks based upon location (Parkinson, Murray, & Mishkin, 1988).

The purpose of the experiments reported in this article is to determine whether or not a natural response, one to which pigeons seem predisposed, could be adapted to a well-researched relational task with pigeons—matching-to-sample. The choice of the response (actually a stimulus–response–reinforcer complex) came from watching doves and feral pigeons search for food. Occasionally, they displaced leaves, twigs, or gravel in their foraging. The idea was to see if pigeons might be predisposed to dig in gravel and learn a relational task, matching-to-sample, with different gravel as stimuli. By making gravel, the material covering grain reward, the discriminative stimulus, then problems (e.g., preferences) and limitations (e.g., limited grain types) associated with making the grain itself the discriminative stimulus (e.g., in grain-on-gravel search experiments; Bond, 1983; Dawkins, 1971; Güntürkün & Kesch, 1987; Jäger, 1990; Siemann & Delius, 1992) would be avoided.

Experiment 1

Matching-to-sample and oddity-from-sample experiments were conducted with white or black gravel placed in small pots with grain buried in the pots appropriate for the task being studied.

Method

Subjects

The subjects were 8, experimentally naive White Carneaux pigeons, 6–7 years old, from the Palmetto Pigeon Plant in Sumter, South Carolina. They were maintained on a 14/10 hr light-on/light-off cycle with water and grit continuously available in their home cage in a state-approved vivarium. Daily experimental sessions were conducted 6 days each week if the pigeons were 77%–83% of their free-feeding weights. Experimental sessions were conducted on 2 pigeons at a time in a separate experimental room.

Apparatus

The apparatus was a plastic tray (21.6 cm wide × 16.5 cm deep × 5.1 cm high) divided into three compartments. There was a hole (5.1 cm) in the base of each compartment to fix and stabilize the gravel pots.
The gravel pots were made of white ceramic (5.4 cm diameter at top, 4.8 cm diameter at bottom, and 3.0 cm high and were used as tropical bird feeders). They were filled with a casting resin leaving a depth of 1.19 cm to be filled with gravel. This depth was sufficient to cover grain placed at the bottom, and the pigeons could easily dig to get to the grain reinforcement. An edge of a machinist rule was used to level the gravel with the top of the pot. Two different types of gravel were used as training stimuli, a coarse white gravel (about 0.64 cm in diameter) and a fine dark-gray gravel (about .32 cm in diameter).

Procedure

Pretraining. Pigeons were trained to dig in a pot of gravel over 4, eight-trial daily sessions. Seeds were buried successively deeper in the gravel, and they learned to spray the gravel out of the pot to get to the buried grain. A single gravel pot containing five seeds (popcorn, white pea, wheat, milo, black pea) was used. The gravel type and right or left location of pot varied quasi-randomly. On Trials 1-2, seeds were placed on top of the gravel. On Trials 3-8, seeds were pushed down so that they were embedded in the gravel. On Day 2, the five seeds were slightly buried but still visible. On Day 3, most seeds were buried with one or two slightly visible. On Day 4, all seeds were buried at the bottom of the pot.

Results and Discussion

Matching and oddity acquisition are shown in the top and middle panels, respectively, of Figure 1. Both groups learned rapidly in at least 4, eight-trial sessions. To look at the learning rate in more detail, performance was averaged for two-trial blocks, across both groups, and is shown in the bottom panel.

This trial-by-trial analysis (bottom panel) shows that after only 10 trials acquisition was apparent and performance rose to about 75%. Thus, acquisition began after only 10 trials, just 2 trials into Session 2. After 26 trials (2 trials into Session 4) performance rose to above 90%. This acquisition rate is much more rapid, by orders of magnitude, than any other of which we are aware, for pigeons learning matching-to-sample.

Pigeons maintained accurate performance of 83.1% correct on training trials throughout transfer testing, but none showed accurate transfer: Overall transfer performance was 49.8% correct (49.2% for colors, 53.1% for texture, 44.6% for rocks, and 52.4% for beads). This lack of transfer is similar to that from pigeons trained on matching with two stimuli in Skinner boxes (Berrymam, Cumming, Cohen, & Johnson, 1965; Cumming & Berrymam, 1961; Cumming, Berrymam, & Cohen, 1965; Dones, 1979; Farthing & Opuda, 1974; Santi, 1978, 1982). As in Skinner boxes, pigeons in this gravel-digging setting apparently must be trained with several stimuli to learn the matching concept and show good transfer performance to novel stimuli (Lombardi, Fachinelli, & Delius, 1984; Wright, Cook, Rivera, Sands, & Delius, 1988). Explanations of transfer failure based upon novelty-averse reactions can generally be ruled out, because after the first few test trials none of the pigeons showed any hesitation to dig in the test pots. Furthermore, any novelty-averse reaction would be expected to diminish by the second transfer test, but there was no indication of better transfer, or indeed any transfer, on the second test.

1 The second-seed-open rule was adopted to maximize the chances that the pigeon would be in neutral position with respect to the side comparison pots and to minimize chances of experimenter-cuing or hesitations in opening side covers on incorrect choices.
approaches control experiments may be necessary to validate it. For example, were the pigeons under discriminative control only of the gravel stimuli and not experimenter-produced or grain-produced (e.g., smell) cues? Did the pigeons learn more rapidly because they had only eight trials per day and had longer ITIs? Poor transfer performance in Experiment 1 would support the first two possibilities, nevertheless we conducted a control test using an experimenter who could not see (blind) the stimuli and therefore did not know which choice was correct. We also conducted another control test baiting both choices (double-baited). For the third possibility, we conducted a control test using a modified Skinner box with eight trials per day (distributed-practice) and ITIs and grain reinforcement matched to the digging task.

Method

Subjects

The subjects in the blind and double-baited tests were 2 White Carneaux pigeons that had acquired the matching task and were 8 and 10 years old. Subjects in the distributed-practice test were 2 experimentally naive White Carneaux pigeons and were 9 and 11 years old.

Apparatus

The apparatus for the blind and double-baited tests was the same as in the previous experiment. The apparatus for the distributed-practice experiment consisted of a video monitor that projected color cartoons from the chamber floor, pecking responses sensed by a touch screen, and grain reinforcement placed on top of the picture (See Wright et al., 1988 for complete details). These aspects of pecking toward the floor and grain reward closely associated with the stimulus added to the similarity between this experiment and the gravel-digging experiments. The cartoon stimuli were color drawings of a duck and apple, and they were chosen to be maximally discriminable so that if learning was slower than in the digging experiments, it would not be due to stimulus discriminability difficulties.

Procedure

The blind and double-baited tests were conducted in four phases with 3, eight-trial sessions per phase: Phase 1 was regular training (baseline), Phase 2 was a blind test, Phase 3 was a baited test, and Phase 4 was a return to baseline. The baseline sessions were identical to those described in Experiment 1 for the matching task. In the blind test, the experimenter manipulating the sample and comparison stimulus covers had no knowledge about the stimulus configuration or which side comparison was correct. The blind experimenter sat below the stimulus tray and reached up to manipulate the doors. Another experimenter prepared the trials in a different portion of the room behind the blind experimenter. After placing the tray on the pigeon's cage the trial-preparation experimenter walked back to the preparation area and turned away from the test situation. The blind experimenter could look through the bottom of the plastic tray and determine when to open and close the side covers. When the trial was completed the trial-preparation experimenter removed the tray and scored the trial.

In the double-baited test, both comparisons were baited with the same number and composition of seeds as had previously been used on baseline trials. During the double-baited test, trials proceeded...
normally following correct choices. However, when pigeons made
correct choices (3 of 48 trials) they were not allowed to dig in the
incorrect pot (cover was closed to avoid reward for incorrect
choices).

The procedure for the distributed-practice experiment was a
slow-paced matching-to-sample. The sample stimulus was dis-
played for 10 s (approximated sample gravel-digging time), and the
next sample peck produced the comparison stimuli. A peck to one
of the two comparison stimuli constituted a choice. Correct choices
resulted in 24 wheat seeds, similar to the gravel-digging ex-
periments. The correct comparison stimulus stayed on for 15 s, which
approximated eating time in the gravel-digging experiments. In-
correct choices resulted in no grain, a 30-s time out (as in the gravel
experiments) with the houselight off, and was followed by a cor-
rection trial. Following correct choices, there was a 288-s (4.8-
minute) ITI with the houselight turned on. Eight trials were con-
ducted with each of the 2 pigeons for 77 days for a total of 616 trials.

Results and Discussion

Results from the blind and double-baited control tests are
shown in Figure 2. A two-way analysis of variance (ANOVA)
for test condition (training, blind test, baited test, and train-
ing) and subjects, with alpha set at .05, showed no significant
differences for test condition, $F(3, 16) = 0.63, MSE = 41.2,$
or for subjects, $F(1, 16) = 0.90, MSE = 58.6,$ and so the
results were pooled across subjects and baselines.

The results validate the procedure in that there were no experi-
menter-produced or grain-produced cues, and thus the
different types of gravel were the discriminative stimuli.

Results from the distributed-practice control test showed
no evidence of acquisition even after 77 sessions (616 trials)
of training. This number of trials is about the same as the
presolution period for subjects trained under traditional con-
tions with these same two stimuli (Wright et al., 1988) but
is orders of magnitude more than the acquisition period for
gravel-digging subjects. Thus, a distributed-practice effect
apparently does not contribute to the faster learning in the
gravel-digging setting.

General Discussion

These learning experiments showed that matching and
oddity, in this gravel-digging setting, were acquired in about
11 trials to a 75% accuracy level and in about 27 trials to
about a 90% accuracy level. This is a much faster learning
rate than in typical key-peck settings (i.e., Skinner boxes),
where with two stimuli (e.g., red & green) matching is ac-
quired in about 1,000 to 1,200 trials (e.g., Carter & Eck-
eman, 1975; Cumming & Berryman, 1961), and oddity is ac-
quired in about 2,000 to 2,500 trials (e.g., Cumming &
Even when color cartoon stimuli are projected from the floor,
two-alternative matching is acquired in about 1,200–1,500
trials (Wright et al., 1988). These acquisition rates can be
somewhat slowed or speeded by changes in the difficulty of
the stimuli (Carter & Eckerman, 1975), viewing conditions
(Wright, 1992), sample response requirement (e.g., Eck-
eman, Larson, & Cumming, 1968; Sacks, Kamil, & Mack,
1972), differential sample requirements (e.g., Urcuioli, 1985;
Urcuioli & Honig, 1980), or differential grain rewards (e.g.,
Peterson, Wheeler, & Trapold, 1980; Trapold, 1970). Such
changes can produce 2–3-fold changes in acquisition rates
but nothing like the 40–100-fold increases showed in these
gravel-digging experiments. The faster acquisition in the
gravel-digging setting would seem to more closely approach
learning in the natural environment where pigeons must rapid-
ly learn to find food and avoid predators.

It may be of some value to discuss some of the differences
that may be responsible for the faster acquisition in the
gravel-digging setting. Critical aspects of the gravel-digging
setting would seem to include: (a) contact with three-
dimensional stimuli, (b) manipulation and scattering of the
(gravel) stimuli, and (c) discovery of grain reward buried
beneath the stimuli. It is interesting to observe that, unlike
many experimental settings, pigeons readily work in the
gravel-digging task with little deprivation. This indicates that
the task itself may be inherently rewarding. We have had
case to test pigeons that have previously participated in
these or similar experiments but that were subsequently re-
turned to free feeding. Although they were at their 100% weight (but prior to their daily feeding), they still accurately
worked the task even after a month or more lay-off.

In conclusion, this rapidly learned matching and oddity
task with gravel stimuli may be better suited than others to
test pigeon cognitive processes. The advantage of this task
over others may even increase as the cognitive demands of the
task increase (e.g., expanding a simple matching task into
a list-memory task). The pigeons are less apt to become conf-
fused because it better fits their predispositions. In addition
to the rapid learning, the ease of instrumenting the gravel-
digging task should make it appeal to cognitive neurosci-
entists and to instructors and students in learning courses.
References


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