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SHORT COMMUNICATION

Pigeon's Behavior as a Discriminative Stimulus

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This study examined whether stimulus control by a conspecific's behavior generalizes to a different location and whether this behavior is maintained in the presence of a new conspecific. Three pigeons were trained to peck a key opposite to that on which another pigeon, the "stimulus bird," was pecking. After training with 2 keys, the third key was introduced. Generalization to this new key position was incomplete although one bird responded to this key during the first session and the other two birds showed some evidence of facilitation by the behavior of the stimulus bird. Next, having confirmed that experimental birds used only the stimulus bird's behavior as a cue to key choice, a new stimulus bird was introduced. All experimental birds correctly responded in its presence indicating that the control was not specific to the individual in the presence of which training occurred.

Stimulus control by the behavior of other members of one's species has attracted attention from researchers as it is thought to be the basis of much of social interaction, such as communication, cooperation, and social learning. Catania (1992, p. 214), for example, pointed out that "the discriminative stimuli provided by other organisms are more important than those provided by inanimate objects and events."

Howard and White (2003) reported that pigeons imitate another's behavior only when they were reinforced in relation to the demonstrator's behavior. They suggested that a critical factor in social learning is that the demonstrator's behavior serves as a discriminative stimulus for the observer. Behavioral control by another member of one's species has been demonstrated in a number of studies. For example, Danson and Creed (1970) showed that a monkey's chain-pulling behavior may serve as a discriminative stimulus for another monkey's response. Millard (1979) showed that high or low rates of responding could serve as discriminative stimuli for pigeons. Mason and Hollis (1962) showed that the location of a monkey's body could serve as a discriminative stimulus for another monkey. Hake, Donaldson, and Hyten (1984) showed that a rat's lever pressing could be controlled by the location of the lever pressed by another rat. Fushimi (1990) showed that lever pressing by a monkey served as a discriminative stimulus for another's responses in a conditional discrimination task.

Skinner (1962) found that stimuli control of behavior by the location of a conspecific generalized to new locations. In his experiment, two pigeons observed each other in chambers that were located side-by-side, each with three keys arranged in a column. On each trial one of three keys in the column was "correct."

This was not signaled. The pigeons could get food by simultaneously pecking the correct key. After the pigeons learned this task, the chambers were interchanged. When one of the birds pecked the wall on the side opposite to the keys, the other bird immediately emitted the same response.

The current experiment represents an extension of this earlier work. Because Skinner's (1962) main concern was to demonstrate cooperation by pigeons, he did not control the pigeon's behavior. Therefore, it is not completely clear that the pigeons really used cues provided by each other. In the present experiment, the behavior that was intended to serve as a discriminative stimulus was brought under stimulus control by the experimenter. This was done in a situation in which the only cues available to the pigeons whose behavior was of interest were those provided by the behavior of the trained pigeons. This experiment tested whether stimulus control by the behavior of a conspecific would generalize to a new location as well as to a new conspecific.

Method

Subjects

The subjects of this study were three experimentally naive pigeons (Columba livia) maintained at about 80% to 85% of their free-feeding weights. They were housed individually in a colony room in which the light on:off cycle was 12:12 h. Grit and water were always available. Three additional pigeons, maintained under the same conditions, served as stimulus birds, that is, their behavior served as the discriminative stimuli for the experimental subjects.

Apparatus

Figure 1 is a diagram of the apparatus. Two chambers (48 x 43.5 x 35.5 cm), mirror images of each other, were separated by a transparent acrylic board. Each chamber had three response keys (each 2.5 cm in diameter) and an associated feeder. In the chamber for the stimulus birds there was a light emitting diode (LED) visible only to the birds in this chamber. Two microcomputers (MSX2, Sony) controlled experimental contingencies.

Procedure

Preliminary training. Preliminary training was done in the absence of another pigeon. In preparation for their role as discriminative stimuli for the experimental birds, the *stimulus birds* were trained to peck a key above the illuminated LED. At the start of each trial one of the three LEDs was lit. The LED was turned off and reinforcement, 2.5 s access to a tray of mixed grain, followed 15 pecks (fixed-ratio 15) at this key. Sessions were 60 trials in length with each trial separated by a 5 s intertrial interval (ITI). At the conclusion of training, the birds reliably pecked the key above which a LED was lit, and made few responses during the ITI. During each of these 60 trial sessions, the three keys were illuminated in a random order with the restriction that each signaled the correct choice on one-third of the trials.

After magazine training, the *experimental birds* were shaped to peck the center key. As the next step, training involved all three keys and all three feeders. First, the same key was "correct", that is, food was made available on five successive trials. The number of successive trials with the same key correct was reduced to three and finally to one with the correct key randomly changing from trial to trial. There were no cues to indicate which key was the correct key for these birds. When the bird pecked the correct key and obtained reinforcement the trial ended. Pecking one of the other keys had no consequences. Each trial was separated by a 5-s ITI. This training in the absence of another pigeon concluded following ten 60-trial sessions.
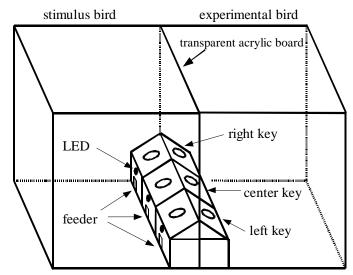
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Figure 1. Schematic of the apparatus. The left chamber was for the stimulus birds, and the right for the experimental birds. Each chamber had three response keys, and three feeders. There was a LED below each key response key in the left chamber.

General Procedure. In all phases of this experiment, except the third, the experimental subject could see the stimulus bird. For the stimulus bird, sessions were 60 trials long with each trial separated by a 5-s ITI and reinforcement was available following 15 pecks on the key above the illuminated LED. In the following discussion, the period from the first to the 15th peck by the stimulus bird, is referred to as the *reinforcement period* (RFT), the period from the 15th key peck to the first peck at the start of a new trial as the *nonreinforcement period* (Non-RFT). For the experimental bird, the correct key (i.e., the key associated with reinforcement), was opposite to the key pecked by the stimulus bird. The duration of reinforcement was 2.5 s for both stimulus and experimental birds. The experimental birds were able to obtain a maximum 60 reinforcements per session by pecking the correct key at least once while the stimulus bird was completing its fixed-ratio 15 schedule. Pecking keys other than the correct one during the RFT period had no effect. Only the first peck made by the experimental bird during the RFT period was used in calculation of the percentage of correct choices.

Phase 1 (Two-Key Condition). In Phase 1 only the left key and the right key were used. For the stimulus bird the order in which these two keys were correct was random except that each was correct on half of the trials and the same key could not be correct for more than three trials in succession. Phase 1 continued for each experimental bird until criterion (better than 90% correct for three successive sessions) was reached.

Phase 2 (Three-Key Condition). Phase 2 was conducted to test whether the control of key choice by the stimulus bird in Phase 1 would generalize to the center key. During this phase the LEDs were associated with all three keys in a random order with the restriction that each key was correct on one third of the trials. Phase 2 was continued until the criterion (better than 90% correct for all responses and better than 90% correct for the center key for five successive sessions) was reached.

Phase 3 (Behavior in the Absence of the Stimulus Bird). The purpose of Phase 3 was to determine whether the behavior of the experimental birds was controlled by cues other than those provided by the stimulus birds. On each trial one of the three LEDs was illuminated for 5 s, the average length of the RFT period. This was followed by the 7.5-s Non-RFT period (the addition of 2.5 s that the feeder would have been operated to the 5-s ITI). As before the experimental bird could obtain food by pecking the correct key during the RFT period. Only the first key pecked during the RFT period was used as a measure of accuracy. Phase 3 consisted of seven 60-trial sessions.

Phase 4 (Identical to Phase 2). The purpose this phase was to test further whether it was the presence of the stimulus birds that was responsible for the accurate behavior observed during Phase 2. This phase consisted of 13 sessions that were identical to those in effect during Phase 2. Following the first three sessions there was an interruption of 80 days during which the experimental birds were not trained. The stimulus birds received sufficient training during this period so that, when

they were returned to their apparatus after 80 days they continued to behave at the same level of accuracy as prior to the interruption. Training was continued for 10 more sessions.

Phase 5 (New Stimulus Bird Condition). Phase 5 was conducted in order to test if the control of the behavior by the stimulus bird would generalize to a new stimulus bird. In all previous phases, each experimental bird was paired with the same stimulus bird. During Phase 5 the conditions were the same as in Phases 2 and 4. However, each experimental bird was paired with a different pigeon. There were five sessions.

Results

Figure 2 shows the total numbers of responses made during the RFT and the non-RFT periods for each of the experimental birds during the five phases of the experiment. At the start of Phase 1, the experimental birds made substantially more than the 60 responses required to obtain all of the scheduled reinforcements. The number of such responses during the RFT decreased to near 60 as training continued. The number of responses during the Non-RFT period also decreased as training continued, however, a substantial number of responses occurred during this period, especially by birds B-2 and B-3. This appears to be due to a carry-over from the 10 sessions of preliminary training during which these birds were trained without distinction between RFT and Non-RFT periods. All birds showed a substantial increase in responding during the non-RFT periods in the absence of the stimulus bird (Phase 3).

The percentage of correct responses based on the first key that was pecked during the RFT period is shown in Figure 3 for each of the experimental birds for the five phases of the experiment. Although only two keys were designated as correct during Phase 1, accuracy at the start of training was close to that expected in the absence of stimulus control in a three choice situation (32% for B-1, 28% for B-2 and 32% for B-3). All three birds reached the criterion of a least 90% correct within 8 sessions. Binomial tests revealed that accuracy was significantly above chance level ($p < 0.001$).

The purpose of Phase 2 was to see whether control by the behavior of the stimulus bird would generalize to the center key. In Phase 2, the center key, as well as the left and right keys, were designated as correct with equal probability. The stimulus birds were well trained with all three keys and when the LED under the center key was illuminated they pecked this key without hesitation. The probability that choices were above chance was evaluated by binomial tests. During the first session, B-1 correctly pecked the center key on 70% ($p < 0.001$) of the trials on which the stimulus bird pecked its center key. B-2 and B-3 did not peck this key in spite of the fact that during preliminary training responses to this key were well established. Percentage correct for the center key, however, rapidly increased and reached 80% ($p < 0.001$) within three sessions. This improvement in performance was faster than the rate of learning shown during Phase 1 suggesting that positive transfer due to observing the stimulus bird's behavior did occur.

In Phase 3 the experimental bird was alone in its chamber. The only difference between these sessions and the previous ones was that the stimulus bird was absent. Accuracy decreased to near a chance level in a three choice situation (22% for B-1, 32% for B-2 and 30% for B-3 averaged across the 7 sessions). As pointed out earlier, responding during the Non-RFT periods increased substantially. However, as soon as Phase 4 began, that is, as soon as the stimulus bird was brought back into the chamber, the three experimental birds returned to the highly accurate
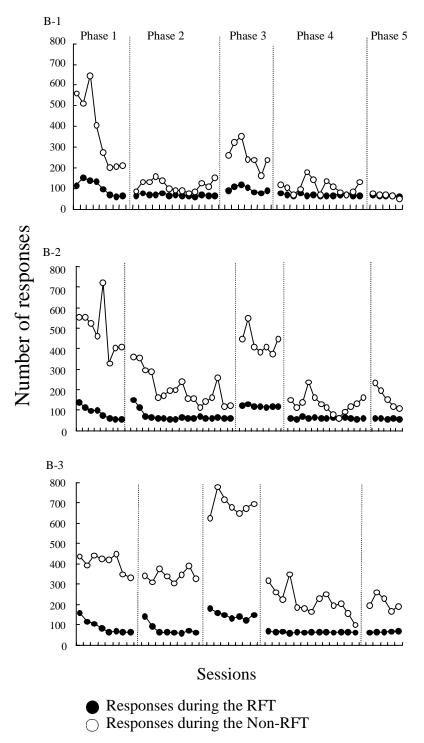
Figure 2. Number of responses during the RFT and the Non-RFT periods for all phases of the experiment. The top panel shows results for B-1, the middle for B-2 and the bottom for B-3.
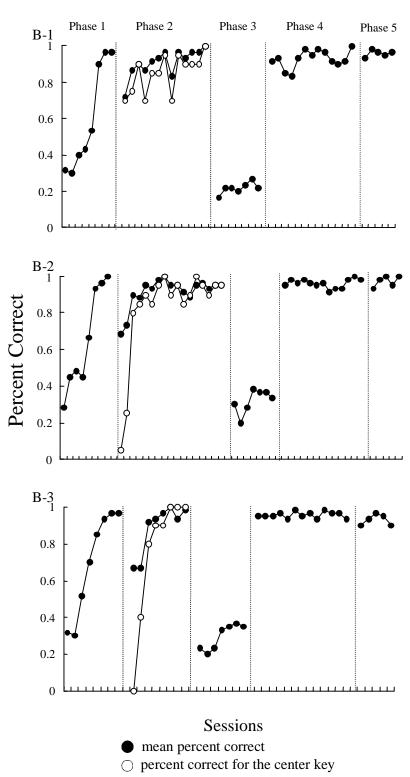
Figure 3. Mean percent correct for all phases. The top panel shows results for B-1, the middle for B-2 and the bottom for B-3. Percents correct for the center key during Phase 2 are also shown.

key choice exhibited during Phase 2. This was accompanied by decreased responding during the Non-RFT periods (see Figure 2), from averages of 252.6, 439.7, and 687.9 (for B1, B2, and B3, respectively) in Phase 3 to averages of 102.9, 134.0, and 217.3 (respectively) in Phase 4. A one-tailed, paired-sample t-test showed this difference to be significant, $t(2) = 3.33$, $p < 0.05$. Thus, these data indicate that the experimental birds responded according to the location and time in which the stimulus bird responded, that is, the behavior of these birds was controlled by the behavior of the stimulus birds.

The introduction of a new stimulus bird in Phase 5 did not disrupt performance, even during the first session. The percentages of correct responses for the first session in Phase 5 were 93% for B-1, 93% for B-2, and 90% for B-3, all significantly above chance level (ps < 0.001). Thus, stimulus control by the location of the behavior of different pigeons generalized almost completely from one individual to another.

Interestingly the number of responses during the Non-RFT period differed among the experimental birds. B-1 made fewer responses during that period from the beginning of Phase 5. On the other hand, B-2 and B-3 made more responses during the Non-RFT period during the first session in Phase 5 than during the last session in Phase 4. This suggests that the temporal control of the behaviour (i.e., when reinforcement was available for pecking the key), was not complete. Although the birds used the information provided by the stimulus bird to choose the correct key, temporal control over the behavior was imperfect.

Discussion

This research shows that the behavior of one bird can serve as a discriminative stimulus for another. The experimental birds in this experiment used the conspecific's behavior as a discriminative stimulus to decide when and where to peck. This extends the finding of Mason and Hollis (1962), who obtained similar data with monkeys, and Hake et al. (1983), who examined this type of stimulus control in rats.

While the experimental birds' percentage of correct responses for all phases, except Phase 3, were consistently high, the birds tended to respond at relatively high rates during Non-RFT periods and this behavior did not extinguish. Why did subjects continue to respond during Non-RFT periods? It was observed that when the stimulus bird's LED was lit and the bird moved towards that key, the experimental birds followed and tended to begin pecking the key before the stimulus bird began its 15 pecks, the start of the RFT period. If only three or four pecks preceded a RFT period a range of about 180 to 240 responses would have been recorded during Non-RFT periods per session. Behavioral stimuli, unlike other physical stimuli such as light, are ambiguous with regard to the onset. These anticipatory responses may have decreased the time to reinforcement. Responses as the time of reinforcement approaches may have functioned much as the anticipatory pecks observed as scallops in fixed interval schedules. If so, such responding would not be expected to extinguish. Perhaps by pecking, the experimental birds were acting like Skinner's (1962) birds in his study of cooperation, prompting the stimulus bird to start responding. Further experimental analysis is needed for understanding Non-RFT responses.

While transfer of stimulus control to the location of the correct key by the behavior of the stimulus birds was not dependent upon a specific bird, transfer of the behavior to a new location, the center key, was only minimally facilitated by observing the stimulus bird. This result is not consistent with Skinner's (1962) observation that following the behavior of a conspecific generalizes to a new location. In the present experiment, unlike in Skinner's experiment, when the birds were first trained in the presence of the stimulus bird (Phase 1) they made a substantial number of nonreinforced responses to the center key. This behavior was extinguished during Phase 1. This may be the reason why only minimal generalization to the new key position was observed during Phase 2.

The excellent transfer of responding to the location of the correct key during Phase 5, when the new stimulus bird was introduced, has not been previously demonstrated for pigeons. However, the fact that this occurred is not surprising. Generalization based on the behavior of others undoubtedly plays an important role in social behavior. For example, a pigeon that learns to use the behavior of a specific pigeon as a means of locating food should be able to use this information when provided by other pigeons.

There are many studies about social learning on foraging in animals living in groups. These include social transmission of food-finding behavior (Giraldeau & Lefebvre, 1987; Palameta & Lefebvre, 1985), producer-scrounger relationships (Giraldeau & Templeton, 1991; Lefebvre & Helder, 1997), and food finding or patch finding (Coleman & Mellgren, 1997). These issues may be thought of in terms of stimulus control by conspecifics.

The present experiment is related to research on local enhancement, "directing attention of associates to a particular object or environmental situation" (Thorpe, 1956, p. 124), in social foraging and social learning. Coleman and Mellgren (1997) reported effects of local enhancement in zebra finches. Pairs of birds were allowed to find food in the same (local enhancement pairs) or a different location (local interference pairs). Local enhancement pairs obtained food more efficiently than the local interference pairs. Local enhancement is thought to be an innate tendency. However, the results of this experiment suggest that a pigeon's ability to direct its attention to the behavior of a stimulus bird reflects its history of reinforcement for pecking the key in front of stimulus bird. Additional studies of stimulus control by conspecifics may show the degree to which learning contributes to social foraging.

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