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The association of visual concepts and imitative vocalizations in the mynah (*Gracula religiosa*)

THOMAS H. TURNEY
New Mexico Tech, Socorro, New Mexico 87801

Birds have been observed to refer to objects such as predators with characteristic vocalizations, but little is known of the processes involved. In order to study this phenomenon, two associations between visual concepts and imitative vocalizations were operantly conditioned in a Greater Indian Hill mynah. The mynah was successfully taught to say "hello" to pictures of persons and then to "bark" to pictures of trees. Correctness and latency data during acquisition and generalization tests to novel pictures are presented. The visual concept-imitative vocalization association paradigm could be useful in studying avian semantics, as well as the evolution and neurophysiology of vocal communication.

Natural observation suggests that some bird vocalizations, for example, alarm calls, can specify environmental referents, such as different types of predators (Marler, 1959; Marler & Green, 1979). Armstrong (1963) listed environmental information as one of three major functions of avian communication. Except for alarm calls, it is the least studied function. For example, the extent to which learning plays a role in such vocal naming is uncertain.

In a laboratory study of vocal naming, Ginsburg (1963) established visual stimulus control over mynah vocal imitations. Two mynahs were operantly conditioned to say "hello" to the onset of a light. One mynah subsequently learned to say "what's up" to a black-and-white cylinder. The simple, physically definable stimuli used by Ginsburg are unlike those normally confronting animals in nature (Herrnstein & Loveland, 1964). Animals must respond to open-ended stimulus classes or concepts. One avian species, the pigeon, has been shown to respond on the basis of concepts, such as "person" and "water" (Herrnstein, Loveland, & Cable, 1976).

If this avian conceptual ability existed in mynahs, the mynah could possibly be trained to give voice to its concepts. The purpose of the present study was to investigate the association of visual concepts and imitative (arbitrary) vocalizations in an avian species. Regardless of how the arbitrary vocalizations came to be imitated, the interest was in establishing an association between that vocalization and a visual concept. Therefore, a Greater Indian Hill mynah was operantly conditioned to respond vocally to positive instances of particular concepts and refrain from doing so to negative instances. The successful transfer of such a discrimination to novel instances has been considered evidence of a concept (Herrnstein & Loveland, 1964).

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METHOD

Subjects

A 1-year-old Greater Indian Hill mynah (*Gracula religiosa*) of unknown sex served as the subject.

Apparatus

A 50 x 135 x 88.5 cm cage was built into a sound-attenuation chamber. A perch, 7.5 cm above the cage floor, extended the width of the cage. On the front wall parallel to the perch, a 20.5 x 20.5 cm rear-projection screen was located 20 cm above the cage floor. A food cup was located below and to the side of the screen. The food cup received 45-mg Noyes rat pellets from a food magazine.

Since the sound-attenuation chamber was closed during experimental sessions, all auditory and visual observation of the subject employed a video recorder and monitor located outside the apparatus. In addition, the experimenter could speak to the subject through a microphone connected to a speaker behind the projection screen. A slide projector located behind the rear-projection screen produced an 11.5 x 17.3 cm image on the screen.

Procedure

While located in a laboratory and the author's office and home, the mynah was shaped to say "hello" over 6 months. After 8 months, it also spontaneously emitted a distinctive imitation of a dog barking outside ("bark"). Both responses were unlike mynah vocalizations. The mynah was subsequently shaped to emit spontaneous "hello" and "bark" responses in the apparatus.

When the frequency of "hello" and "bark" responses had reached asymptote (approximately 50 total responses per session), pretraining began. During pretraining, three types of 35-mm color transparencies were projected onto the screen in a counterbalanced sequence for 15 sec each. The mynah was rewarded for responding either "hello" in the presence of a circle on a yellow background or "bark" in the presence of a rectangle on a blue background. A correction procedure was

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used. Uniformly gray pictures were also presented in the stimulus sequence. Vocalizing "hello" or "bark" to the gray pictures was not rewarded and restarted the trial after a 5-sec penalty. Modeling training was used in which the experimenter spoke the correct response 7.5 sec after the onset of the picture. If the mynah responded correctly before 7.5 sec, the experimenter remained silent. A correct response was rewarded with two pellets. The next picture was not presented until the mynah returned to the perch after consuming the reward. Pretraining continued for 32 days with three 20-min sessions per day.

On Day 1 of the experiment, person-concept training began with the presentation of a training series of positive and negative instances of the "person" concept. The person pictures consisted of four copies of 10 different pictures of a person, persons, or portions of a person. The nonperson pictures consisted of 40 different pictures of objects and landscapes that contained no persons or trees. For each series, the person and nonperson pictures were randomized and then placed in a successive counterbalanced sequence. The counterbalanced sequence was interrupted during the middle one-third of each session by placing together three positive and then three negative instances (or vice versa). This was done to test the extent to which the mynah might be responding on the basis of the counterbalanced sequence. The mynah's behavior was not disrupted by the interrupted sequence.

The 80 pictures were presented for 15 sec each unless a response was made. A correct "hello" response to a person picture produced two 45-mg Noyes pellets and advanced the next picture after the mynah had consumed the pellets and returned to the perch facing the screen. The interval between delivery of the reward and facing the perch was approximately 5 sec. A correction procedure was used so that a "bark" to a person picture prolonged the trial until the mynah made the correct "hello" response. An incorrect "hello" or "bark" to a nonperson picture resulted in the trial being restarted after a 5-sec penalty. Person-concept training continued for 10 days with 3 sessions/day. Correctness and latency from picture onset to vocalization onset were recorded for each trial. In all analyses, only the first response on a trial was counted.

On Day 11, person-concept testing began with the introduction of 40 different, novel person pictures and 40 novel nonperson pictures. Five novel sets of 80 pictures were presented. The first novel set was presented for 15 sessions and the remaining four sets, for 6 sessions each. The same apparatus and procedure used for person-concept training was used. Correctness and latency to respond were recorded for each trial.

On Day 21, tree-concept training began with the presentation of a training series of tree and nontree pictures. Four copies of 10 different tree pictures comprised the positive instances. The negative instances included 40 pictures of assorted objects and landscapes containing no trees or persons. The "bark" response was correct for tree pictures. No person pictures were presented, and "hello" was an incorrect response on any trial. Thirty sessions were given in tree-concept training. The same procedure was used as for person-concept training, except that modeling was used in the four initial sessions to stimulate vocal responding.

On Day 31, tree-concept testing began with the introduction of the first of five sets of 80 novel tree and nontree pictures. The first transfer set was presented for 14 sessions and the remaining four sets, for 6 sessions each. The procedure was the same used for the person-concept testing sessions.

RESULTS

During pretraining, the mynah quickly learned a discriminative strategy of not vocalizing to the gray pictures and vocalizing "hello" followed by a "bark" (when no reward was given) to the circle-on-yellow and rectangle-on-blue pictures. Thus, the mynah did not learn to discriminate between pictures using different vocal responses, but it discrimated between negative and positive stimuli on the basis of silence vs. "hello" or "bark." Because of the failure of pretraining procedures to establish two concurrent visual stimulus-imitative vocalization associations, training proceeded to first establishing a person-"hello" association, followed separately by the subsequent establishment of a tree-"bark" association.

Person-concept training was conducted in 24 sessions. Discriminative "hello" responding between person and nonperson pictures emerged rapidly in Session 2 (χ^2 = 12.58, $p < .001$). Table 1 displays the mean number of correct and incorrect "hello" responses and "bark" intrusions during training. Seventy-seven percent of the "bark" intrusions were given to person pictures. The latency to respond "hello" to person pictures did not change significantly over training sessions. In the first seven sessions, the mynah responded "hello" with significantly longer latencies to nonperson pictures (mean = 5.85 sec) than to person pictures (mean = 3.82 sec) [$t(6) = 7.82$, $p < .001$].

Following training, person-concept testing began with the introduction of 40 different, novel person pictures and 40 novel nonperson pictures. Figure 1 displays the proportion correct responses over the 30 person-concept testing sessions. The first set of 80 novel pictures was discriminated more slowly than the training series. In the first transfer session (Session 25), the mynah did not respond above chance; however, in Session 26, performance was better than chance (χ^2 = 18.35, $p < .001$) when "hello" was given to 39 of 40 person pictures and 23 of 40 nonperson pictures.

The subsequent four transfer tests in person-concept testing were conducted for six sessions each. In the four

Table 1
Mean Vocal Responses Per Session During Concept Training

Mean Responses	Concept Training: Person	Tree
Correct	36.63	22.70
Incorrect	2.96	1.04
Positive Intrusions	1.13	13.09
Total Intrusions	1.46	14.09

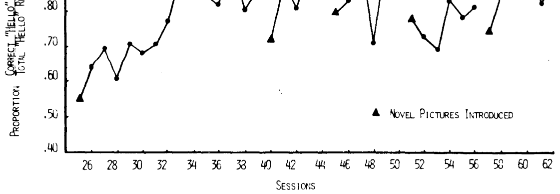

Figure 1. Proportion correct "hello" responses during person-concept testing.

sessions in which novel pictures were first introduced, the mynah vocalized "hello" more frequently to the novel person pictures but refrained from doing so to novel nonperson pictures ($\chi^2 = 124.26$, $p < .001$). Table 2 presents the frequency of "hello" responses for 160 novel person and 160 novel nonperson pictures for the four initial transfer sessions. The latency to respond "hello" over all transfer sessions did not differ significantly for person (mean = 3.44 sec) and nonperson (mean = 3.55 sec) pictures.

Subsequent to the last person-concept testing session the mynah was transferred to the tree-concept training sessions in Session 64. Thirty sessions were given on the training series of tree vs. nontree pictures. In the first two sessions, the mynah began to extinguish vocal responding because (1) "hello" was no longer rewarded and (2) the rewarded conjunction of a tree picture and a "bark" was infrequent. Therefore, in Sessions 64-67, the experimenter reinstated modeling training for four sessions. Only data from Sessions 68-90 have been included in the analysis of tree-concept training.

In Session 70, the mynah responded to four tree pictures with "bark" and 35 tree pictures with "hello" but, correctly, did not vocalize to nontree pictures. Table 1 contains the mean number of correct and incorrect "bark" responses during training, as well as "hello" intrusions. "Hello" intrusions did not extinguish to less than 10 per session until Session 79. Ninety-three percent of the intrusions were given to tree pictures. The stimulus discrimination was learned quickly and maintained, but response differentiation between "hello" and "bark" was only gradually acquired as "hello" intrusions extinguished. The mynah learned the discrimination using the "hello" followed by "bark" strategy and thus made few incorrect "bark" responses as "hello" extinguished. The latency to respond to tree pictures with a "bark" decreased significantly over training sessions [$t(6) = 3.15$, $p < .02$].

For tree-concept testing, the mynah was transferred in Session 91 to the first set of novel tree and nontree pictures for 14 sessions. Figure 2 shows the proportion of correct responses during tree-concept testing. The mynah performed at chance level in the first transfer session, but in the next session (Session 92), performance was better than chance ($\chi^2 = 6.24$, $p < .025$). Performance remained at significantly correct levels thereafter. Intrusions of "hello" averaged 5.69 per session, but only 49% were used for tree pictures.

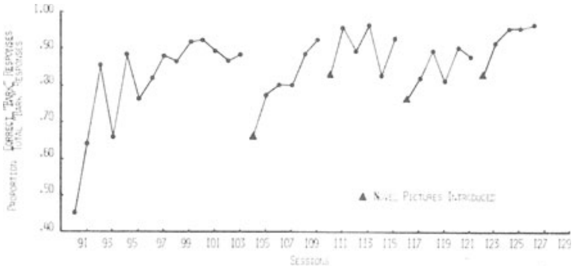

Figure 2. Proportion correct "bark" responses during tree-concept testing.

Following the first transfer set of pictures, four consecutive transfers to novel sets were conducted for six sessions each. Figure 2 gives the proportion of correct responses during these transfer sets. Table 2 presents the frequency of responses for 160 novel tree and 160 novel nontree pictures for the first sessions on the four transfer sets. The mynah vocalized "bark" frequently to tree pictures and refrained from doing so to nontree pictures ($\chi^2 = 132.49$, $p < .001$). Intrusions of "hello" diminished to a mean of 1.26 per session over transfer sessions. The latency to respond "bark" over all transfer sessions was significantly [$t(21) = 2.27$, $p < .05$] longer for tree (mean = 4.44 sec) than for nontree (mean = 4.20 sec) pictures.

In comparing the two associations, the tree-"bark" association was originally subject to more intrusions than the person-"hello" association, but performance was equivalent in initial transfer sessions (see Table 2) and was more consistent over all sessions (see Figures 1 and 2). Over all sessions, on the second through fifth concept testing sets, significantly fewer errors were made on the tree-"bark" association ($t = 2.66$, $p < .02$) and the latency to respond correctly was longer for the tree-"bark" association (mean = 4.44 sec) than for the person-"hello" association (mean = 3.44 sec) [$t(18) = 8.79$, $p < .001$].

Table 2
Frequency of Responses to Novel Pictures During Concept Testing

Response	Picture			
	Person	Nonperson	Tree	Nontree
"Hello"	147	50		
Not "Hello"	13	110		
"Bark"			146	45
Not "Bark"			14	115
Total	160	160	160	160

DISCUSSION

The present study provides evidence that at least one avian species, the Greater Indian Hill mynah, can acquire an association between a visual concept and an imitative vocalization. This ability was not specific to a particular concept, to a particular vocalization, or to the one subject used in the present study. Previous studies have found equivalent results in two other mynahs (Turney, Note 1, Note 2).

The mynah quickly learned either to inhibit the vocal response or to respond with one or both of the imitative vocalizations. The visual concept appeared to form prior to the use of the proper alternative vocalizations. Typically, during training, intrusions were used for the positive instances of the concept.

The latency data demonstrates the rapid nature of the discriminative process. The mynah scanned the complex pictures with lateral head movements and usually either responded vocally or did not respond within 3-5 sec. Stimulus characteristics of the picture did not seem to affect latency. The latency was longer, however, for the less dominant "bark" response. The necessity of first inhibiting the dominant "hello" response prior to the "bark" might account for the longer latency.

Like humans, birds are both visually gifted and vocally plastic. The convergence of these two traits seems to have produced a similarity in vocal environmental reference that is, as far as is known, not shared with other animal species, including our nearest relatives in the primate order. Despite its relatively primitive structure, the avian brain can form visual concepts, imitate vocal patterns, and associate the two.

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