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"Symbolic Communication" Between Two Pigeons (*Columba livia*) Without Unconditioned Reinforcement

David Lubinski
University of Minnesota

Kenneth MacCorquodale
University of California, San Diego

This study addressed the question: Can nonhuman organisms be conditioned to respond discriminatively to abstract features of their environments without unconditioned reinforcement? It demonstrated that two pigeons can be conditioned to maintain an interaction in which one pigeon has access to a discriminative stimulus that the other needs in order to emit a reinforced response, and responds in the absence of deprivation, aversive stimulation, and unconditioned reinforcement. This finding adds to the class of variables heretofore demonstrated to maintain "symbolic repertoires" and highlights a fresh paradigm for conditioning other spontaneous interactions between and within nonhuman species. The importance of social stimuli in such interchanges is demonstrated.

In the early 1970s, Cullen (1972) asserted that "the term 'animal communication' has often been used to refer to the kinds of signals which pass to and fro between social animals and help to mould each others' behaviour towards some goal which is to their mutual advantage" (p. 101). These "signals" are typically restricted to species-specific responses that communicate the presence or location of an unconditioned reinforcer (e.g., food, an unconditioned positive reinforcer; or a predator, an unconditioned negative reinforcer).

Recently, the domain of interanimal communication has been expanded to show that nonhuman organisms can learn to "communicate symbolically" or, more technically, that they can be conditioned to supply S^Ds for each other's behavior (social communication) and that the S^Ds they supply can be only arbitrarily matched with some aspect of the environment (hence "symbolic," not iconic). Savage-Rumbaugh, Rumbaugh, and Boysen (1978) conditioned primates to supply geometric symbols for another subject's food-reinforced responses, and Epstein, Lanza, and Skinner (1980) conditioned pigeons in a similar fashion to interact by pecking lettered response keys. In both of these experiments, the correct response to a symbol (letter or geometric form) was reinforced with food. The question naturally arises: Can these species maintain such interactions in the absence of unconditioned reinforcement? In the present study, we investigated this possibility by conditioning such "symbolic communication" repertoires in nonhuman organisms without deprivation, aversive stimulation, or unconditioned reinforcement.

The procedural and experimental phases of this experiment were based on Skinner's (1957) formulation of verbal behavior. According to Skinner, verbal behavior is behavior that is reinforced through the mediation of other organisms. Although Skinner identified several classes of verbal behavior, only two are relevant to the present investigation, mands and tacts. Verbal responses that are controlled by motivational states are identified as *mands*: A mand is defined as "a verbal operant in which the response is reinforced by a characteristic consequence and is therefore under the functional control of relevant conditions of deprivation or aversive stimulation" (Skinner, 1957, pp. 35–36). Mands are distin-

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Requests for reprints should be sent to David Lubinski, Department of Psychology, Elliott Hall, University of Minnesota, 75 East River Road, Minneapolis, Minnesota 55455.

guished from verbal responses controlled by environmental stimuli, which are identified as *tacts*. A tact is defined as "a verbal operant in which a response of a given form is evoked (or at least strengthened) by a particular object or event or property of an object or event" (pp. 81–82). A "pure" tact shows no influence of any specific motivational state. It is objective and does not covary with the particulars of the speaker's deprivation or aversive stimulation, and it does not maintain a one-to-one relation with a specific reinforcer.

This distinction indicates that the responses conditioned in previous studies (Epstein et al., 1980; Savage-Rumbaugh et al., 1978) were not pure tacts; they were jointly controlled by S^Ds *and* deprivation for the specific reinforcer involved. Our investigation demonstrates that pure tacts can be conditioned in nonhuman organisms and can be maintained in interanimal interactions. One way to free the tact from specific motivational control is to maintain it by generalized conditioned reinforcers. Generalized conditioned reinforcers are stimuli that were initially neutral but have acquired reinforcing efficacy through pairing with *two or more* unconditioned reinforcers. By this process a generalized conditioned reinforcer's effectiveness becomes independent of the behaver's current motivational state (MacCorquodale, 1969; Segal, 1977).

Method

Subjects

Subjects were two experimentally naive male Birmingham rollers (*Columba livia*).

Apparatus

The experimental apparatus is illustrated in Figure 1. It consisted of two adjoining experimental chambers, separated by a Plexiglas divider; each chamber was supplied with an individual panel on which the subjects received discriminative stimuli for choice responses (pecking) that in turn provided an S^D on the adjoining subject's panel. For our generalized conditioned reinforcer, we used an intermittentenly flashing (one per second) light (notated S^{Gcr} in Figure 1). Other details of the two chambers differed in ways that are described below.

Procedure

The procedures replicate parts of Epstein et al.'s (1980) procedure but with some significant variations.[1] We refer to our subjects as the "mander" and "tacter" from the outset, although they met the requirements for manding and tacting only later in the proceedings. Each subject was first independently conditioned to play its role in the interaction presented in Table 1. The pigeon designated the tacter was conditioned in the right chamber; the mander was conditioned in the left chamber (see Figure 1). All responses emitted by the mander technically qualify as impure mands, jointly controlled by deprivation and by the S^D currently present. The mander was maintained at 85% of its free-feeding weight throughout this experiment, and all of its discriminative responses, if correct, were reinforced with food. The tacter, however, emitted both mands and tacts Its initial responses in each chain were tacts, discriminatively controlled by S^Ds and reinforced by an S^{Gcr}, the flashing light. This contingency was maintained whether the bird was hungry, thirsty, both, or neither. Thus control was through the S^D. The tacter's responses to the food or water keys were primarily mands; they were reinforced with food or water, depending on which key was pecked. *Control was, in a sense, through the reinforcer.*

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[1] In contrasting our procedure with that of the Epstein et al. study, two additional variations are noteworthy. First, the tacter's sample key was in plain view of the mander, rather than being recessed behind a curtain. Second, neither bird was required to look through the Plexiglas to see the letters or colors on the other bird's panel, because these were instead projected onto the keys on their own individual panels. These changes are of no consequence to the main purpose of the present study because our central concern was with the specific nature of the tacter's behavior rather than the mander's. We wanted to know whether the tacter would continue to arbitrarily match the letters (i.e., "tact") when it was satiated and received no unconditioned reinforcers for matches. We omitted the curtain because we suspected that it might be sufficiently aversive to suppress the tacter's matching behavior when the bird was satiated. In any event, the fact that the tacter's sample key was in plain view of the mander did not enhance the mander's arbitrary matching accuracy. We know this because in Conditions 2 and 3, when an opaque barrier covered the Plexiglas, preventing the mander from seeing the tacter's sample key, *the mander's matching accuracy* was not attenuated. Also, direct observation suggested that although the mander did attend to changes in the illumination of the tacter's several sample and comparison keys, it did not attend to the specific S^D features of these stimuli. In fact, at the end of this experiment we scrambled the S^Ds interchanged by the tacter and mander (in a quasi-random fashion), so that on 66% of the trials the color that appeared on the mander's sample key was not the one previously matched by the tacter. The mander accurately matched the sample on its own key, as before.

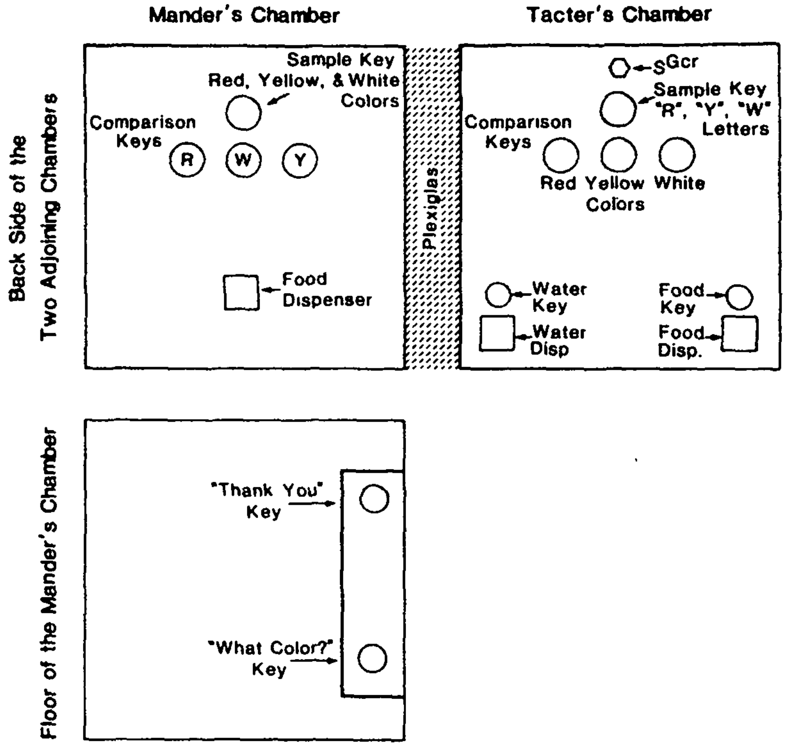

Figure 1. The experimental apparatus. (Adjoining keyboards for the two birds were separated by a Plexiglas barrier. The mander's keyboard is on the left and the tacter's is on the right. The procedure is given in Table 1.)

The tacter's procedure. In the first step of the tacter's procedure, the bird, which was food deprived on some days, water deprived on others, and occasionally both food and water deprived, according to a quasi-random schedule, learned to peck separate keys for food and water. These responses were reinforced only if the S^{Gcr} light was flashing. In this way, the flashing light was paired with both food and water, two distinct unconditioned reinforcers, and so met the requirements for establishing it as a potential S^{Gcr}. Regardless of the tacter's state of deprivation, when the S^{Gcr} was flashing, responses to both the food and the water key were followed by their corresponding reinforcers. Even on days when the tacter was under only one state of deprivation, it typically responded for, received, and consumed both food and water. Pecks on the food key resulted in access to mixed grain for 4 s; pecks on the water key caused 0.4 ml of water to be dispensed.

Once the flashing S^{Gcr} reliably controlled pecks on the food and water keys, conditions were changed such that the tacter was required to perform successfully an arbitrary matching-to-sample task to cause the S^{Gcr} to flash: the letters R, W, and Y were presented quasi-randomly on the sample key, and the tacter was conditioned to peck the sample key first and then the appropriately colored comparison key, red, white, or yellow. Correct matching responses were reinforced by the flashing S^{Gcr} light, and then a peck on the food or water key was reinforced with food or water, as before. Hence, the matching-to-sample task became the first link in a two-component chain, with pecks on the food or water key as the second component.

The mander's procedure. The mander, on the other hand, first learned to match each color as it was presented on its sample key to the corresponding letter on a comparison key. A correct matching response was directly reinforced with food. After the bird became 90%–95% proficient at this task, two additional requirements were added: The mander was required to "ask for" a sample color by pecking an illuminated key located at floor level (Figure 1) labeled "What color?" This response illuminated a second floor key labeled "Thank you," and a peck on this key then projected a color onto the mander's sample key. Hence, for the mander, the arbitrary matching-to-sample task was the terminal link of a three-component chain in which the first link required a peck on the illuminated "What color?" key and the second link required a peck on the illuminated "Thank you" key.

Both the mander's and tacter's performances were conditioned through standard fading, shaping, and chaining procedures (Catania, 1979). After each bird had mastered its individualized chain schedule to 90%–95% accuracy, both were placed in their chambers concurrently for approximately 1 hr on five occasions. During these periods only the house lights and noise generator were operating. The birds were in

Table 1
The Complete "Verbal" Episode

	Component 1
Mander:	The mander's "What color?" key is illuminated, and the mander pecks it, which advances the chain to Component 2.
	Component 2
Tacter:	A letter is projected onto the tacter's sample key. The tacter matches a color to the letter (i.e., it pecks the letter projected on its sample key and then the appropriate comparison color). If the tacter errs, the house lights in its chamber are dimmed for 3 s, and the conditions of Component 1 are reinstated. A correct match advances the chain to Component 3.
	Component 3
Mander:	The "Thank you" key in the mander's chamber is illuminated. The mander pecks the "Thank you" key, which advances the chain to Component 4
	Component 4
Mander:	The color previously pecked by the tacter appears on the mander's key.
Tacter:	The S^{Gcr} begins to flash in the tacter's chamber.
	Component 5
Mander:	The mander matches a letter to the color projected on its sample key (i.e., it pecks the color and then the appropriate comparison letter). This response is reinforced with mixed grain. If the mander errs, the house lights in its chamber are dimmed for 3 s, and the conditions of Component 1 are reinstated. At the end of this component (i.e , after the mander is rewarded or finishes a time-out), the conditions of Component 1 are reinstated.
Tacter:	The tacter receives either mixed grain or water by pecking the appropriate key. On satiated days, it receives only the S^{Gcr}, and pecks on the food and water keys are not reinforced.

plain view of each other through the Plexiglas divider. This measure was taken to dissipate emotional responses evoked by the sight of a strange bird.

The interanimal interaction. In the next phase of the procedure, the two birds were placed in their chambers concurrently, and the S^D for each link of their respective chains was made contingent on the other bird's behavior. The sequence began when the mander pecked the illuminated "What color?" key. This response automatically caused a letter to appear on the tacter's sample key. The tacter then matched to sample (i.e., it pecked the letter projected on its sample key and then the comparison color key that corresponded to the sample letter). This response illuminated the "Thank you" key in the mander's chamber. (If the tacter made an error, the house lights in its chamber were dimmed for 3 s after which the mander's "What color?" key was again illuminated and the sequence began from the start.) When the mander pecked the "Thank you" key, two things ensued: The tacter's S^{Gcr} began to flash, and the comparison color previously pecked by the tacter appeared on the mander's sample key.

From this point each bird's behavior was independent of the other's; with the S^{Gcr} flashing, the tacter could receive either food or water by pecking the appropriate key, and the mander could receive food by correctly matching the color on its sample key to the corresponding letter on its comparison keys. (If the mander incorrectly matched to sample, its house lights were dimmed for 3 s, and its portion of the trial was aborted without reinforcement.) The S^{Gcr} was programmed to flash until the tacter pecked either the food or the water key; at that point the flashing S^{Gcr} terminated, and the tacter received an unconditioned reinforcer. (If the tacter did not peck either key, the flashing S^{Gcr} terminated at the end of the mander's reinforcement period.)

Both birds learned this interaction with amazing speed, and in 1 week they were maintaining a series of successful interchanges of discriminative stimuli by means of arbitrary matching tasks with greater than 90% accuracy. The interlocking performances resembled a spontaneous conversation. After each bird completed a component link in the sequence, it usually attended to the activities in the adjacent chamber; for example, after consuming either food or water, the tacter typically walked over to the region of the mander's "What color?" floor key and waited. When the "What color?" key became illuminated, the tacter usually began to peck on the Plexiglas directly above the mander's "What color?" key. The mander then

Table 2
Percentage of Correct Responses for Each Bird and Their Correspondence

Day	Tacter condition	Tacter[a]	Mander[a]	Correspondence[b]
		Condition 1		
1	D	32/36 = .89	31/32 = .97	.86
2	S	23/33 = .70	22/23 = .96	.67
3	D	28/36 = .78	28/28 = 1.0	.78
4	S	20/21 = .95	19/20 = .95	.90
5	D	52/60 = .87	50/52 = .96	.84
6	S	28/29 = .97	26/28 = .93	.90
7	D	51/67 = .76	49/51 = .96	.73
8	S	22/25 = .88	22/22 = 1.0	.88
9	D	54/64 = .84	52/54 = .96	.81
10	S	19/25 = .76	17/19 = .89	.68
11	D	50/61 = .82	50/50 = 1.0	.82
12	S	33/38 = .87	32/33 = .97	.84
13	D	55/60 = .92	53/55 = .96	.88
14	S	25/28 = .89	24/25 = .96	.85
15	D	40/42 = .95	39/40 = .98	.93
16	S	10/11 = .91	9/10 = .90	.82
17	D	53/59 = .90	50/53 = .94	.85
18	S	15/16 = .94	11/15 = .73	.69
19	D	57/64 = .89	54/57 = .95	.85
20	S	20/26 = .77	18/20 = .90	.69
21	D	47/55 = .85	45/47 = .96	.82
22	S	6/8 = .75	6/6 = 1.0	.75
23	D	41/45 = .91	41/41 = 1.0	.91
24	S	15/23 = .65	15/15 = 1.0	.65
25	D	53/58 = .91	50/53 = .94	.86
26	S	19/31 = .61	19/19 = 1.0	.61
27	D	53/66 = .80	50/53 = .94	.75
28	S	16/25 = .64	16/16 = 1.0	.64
29	D	67/84 = .80	63/67 = .94	.75
30	S	19/34 = .56	19/19 = 1.0	.56
		Condition 2		
31	D	47/49 = .96	40/47 = .85	.82
32	D	35/35 = 1.0	34/35 = .97	.97
33	D	43/49 = .88	40/43 = .93	.82
34	D	58/62 = .94	57/58 = .98	.92
35	D	53/58 = .91	52/53 = .98	.89
		Condition 3		
36	S	18/20 = .90	18/18 = 1.0	.90
37	D	50/50 = 1.0	48/50 = .96	.96
38	S	6/7 = .86	5/6 = .83	.71
39	D	48/51 = .94	46/48 = .96	.90
40	S	7/7 = 1.0	6/7 = .86	.86
41	D	56/60 = .93	55/56 = .98	.91
42	S	3/5 = .60	2/3 = .67	.40
43	D	57/58 = .98	54/57 = .95	.93
44	S	12/14 = .86	9/12 = .75	.65
45	D	28/32 = .88	26/28 = .93	.82
46	S	3/4 = .75	2/3 = .67	.50
47	D	45/48 = .94	43/45 = .96	.90
48	S	0/2		
49	D	45/50 = .90	41/45 = .91	.82
50	S	3/4 = .75	2/3 = .67	.50
51	D	45/49 = .92	39/45 = .87	.80

Table 2 (*continued*)

Day	Tacter condition	Tacter[a]	Mander[a]	Correspondence[b]
52	S	0/1		
53	D	59/63 = .94	52/59 = .88	.83
54	S	0/1		
		Condition 4		
55	D	54/100 = .54	52/54 = .96	.52
56	D	57/65 = .88	54/57 = .95	.84
57	S	2/2 = 1.0	1/2 = .50	.50
58	D	51/54 = .94	38/51 = .75	.71
59	S	5/6 = .83	3/5 = .60	.50
60	D	56/58 = .97	42/56 = .75	.73
61	S	15/15 = 1.0	12/15 = .80	.80
62	D	61/62 = .98	54/61 = .89	.87
63	S	2/2 = 1.0	2/2 = 1.0	1.00
64	D	42/46 = .91	42/42 = 1.0	.91
65	S	7/12 = .58	7/7 = 1.0	.58

Note All sessions were 45 min in length except for those in Condition 2 which were 1 hr. Before Condition 4 began, a 1-day transition session was implemented, which consisted of the tacter's being 23-hr food and water deprived (Day 55). S = satiated; D = deprived of food and water.

[a] In the fractions, the denominator is the total number of matching responses, and the numerator is the number of correct matching responses. Because the opportunity for the mander to engage in matching was contingent on the tacter's accuracy, the denominator for the former equals the numerator for the latter [b] The product of the two fractions represents the percentage of correct correspondence.

typically hurried over and pecked the "What color?" key and then walked over to the "Thank you" floor key and waited for it to become illuminated by the tacter's matching response. If the tacter was at all sluggish, the mander rapidly pecked the Plexiglas as though impatient. Similarly, if the mander was the least bit hesitant about pecking the "Thank you" key, the tacter would peck the Plexiglas directly above the "Thank you" key Typically, however, each bird was quick in completing its next link, and these "impatient" pecks were few in number, but they did regularly occur if either bird paused. After each interchange, the "What color?" key was illuminated, and, usually without hesitation, the mander pecked it, manding the tacter to match another letter, and the cycle proceeded. On alternating days the tacter was either 23-hr food deprived or 23-hr water deprived, and on a few occasions it was both food and water deprived.

At this point the training was complete. Both birds were emitting discriminative responses derived from an arbitrary matching-to-sample task under the control of socially supplied discriminative stimuli. After observing this interanimal interaction for approximately 3 weeks during which accuracy remained high on both sides, we decided to test whether the tacter's performance could be maintained *without* deprivation and unconditioned reinforcement in order to ascertain whether the performance could be maintained with the tacter emitting *only* tacts.

For the next 5 days, the tacter was returned to its home cage and given free access to both food and water. The birds were then returned to the experimental chambers.

For 30 days the tacter was deprived and satiated on alternate days (A = deprived, B = satiated). Each day's session lasted 45 min. The 15 odd-numbered days of the A condition essentially reinstated the conditions of the original experiment, that is, on those days the tacter was approximately 22.5-hr food and water deprived. In the B condition, however, the tacter was food and water satiated (i.e., it had free access to both food and water for approximately 23 hr prior to each B session). Moreover, on the even-numbered B days, the food and water keys were disconnected from their respective dispensers so that no unconditioned deprivation-relevant reinforcers were delivered. All of the remaining contingencies were as before; when the mander pecked the "Thank you" key, the S^{Gcr} flashed in the tacter's chamber, but that was the only consequence of a correct match by the tacter. The results are summarized in Table 2

Results

Condition 1

Table 2 shows that the tacter did not stop matching colors to the letter samples in the B condition, even though the bird was food and water satiated and matches were not followed by food or water (see Figure 2). Thus, the "verbal" behavior emitted by the tacter in the B condition involved only tacts. In the B condition, the tacter's matches were 79% accurate; in the A condition, 86% accurate. Under either

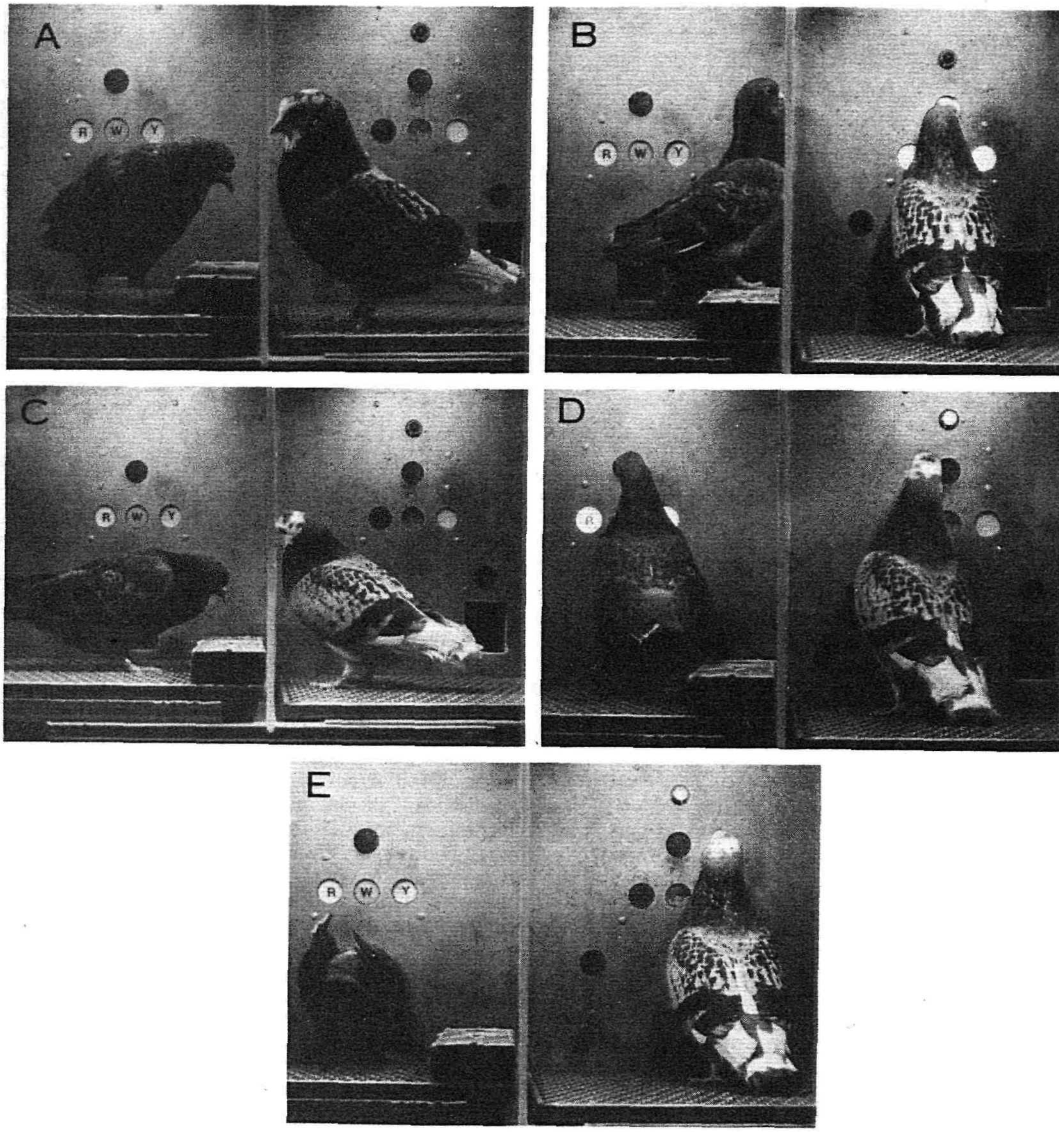

Figure 2. A two-pigeon exchange involving tacting. (Upper left: The mander [left] asks the tacter [right] to match [i.e., tact] the letter projected on its sample key. Upper right: The tacter matches a color to the letter. Middle left: The mander pecks the "Thank you" key, which rewards the tacter with the flashing S^{Gcr}; this response also presents to the mander the color previously pecked by the tacter. Middle right: The mander matches a letter to the color projected on its sample key as the tacter turns toward the S^{Gcr}. Bottom: The mander is rewarded with food for correctly completing the "symbolic" exchange, and the tacter attends to the flashing S^{Gcr}.)

condition, the accuracy was significantly greater than chance (33%). More important, the difference in accuracy on A versus B days was not significant statistically. What did differ significantly between the two conditions, however, was the *frequency* of responses emitted by the tacter. In the deprived condition, the tacter emitted an average of 48.9 matches per session; in the satiated condition, an average of only 19.3 ($p < .001$). This resulted because the bird tended to pause before pecking the letter on its sample key when the mander asked, "What color?".

The interaction between the two birds became interestingly elaborated on the tacter's B days. During the long periods of the tacter's pausing, the mander exhibited typical pigeon "aggressive display" behavior seemingly directed toward the tacter, pacing back and forth along the Plexiglas divider and pecking at the Plexiglas.

The tacter's behavior was also elaborated on its B (satiated) days. On some occasions, after receiving the S^{Gcr} the bird pecked the food or water key, even though it was satiated and these keys were inoperative. At other times it merely attended to the flashing light until the light terminated. On still other occasions, the tacter displayed emotional behavior, such as wing flapping, aggressive displays directed toward the mander, and occasionally pecking of the Plexiglas. This emotional behavior seemed to be in response to the emotional behavior of the mander (which typically became more intense the longer the tacter paused). On several occasions, however, the tacter's matching response occurred when the mander was relatively still and not emitting any noticeable behavior (sometimes even standing with its back toward the tacter).

Because of these dynamic aspects of the interaction, Travis Thompson (personal communication, 1982) suggested that the audience (i.e., the mere presence of the mander, and its impatient behavior) might be critical for maintaining the tacter's matching behavior. To test whether this was the case, we isolated the birds from each other by covering the Plexiglas barrier with an opaque divider. The same contingencies were left in place at the end of Condition 1 except now the birds were unable to see each other.[2]

Condition 2

Condition 2 was a brief period of adaptation to the novel barrier. For all 5 days of this phase, the tacter was approximately 22.5-hr food and water deprived. Each session lasted 60 min. The data in Table 2 reveal that the accuracy of responses for this condition remained high. However, the interaction lacked the pace observed in Condition 1. In Condition 1, after completing a response, both birds had attended to the key light changes in the adjoining chamber as well as to the behavior of the other bird. With the opaque divider in place, these stimuli were missing, and each bird tended to move about in its respective chamber after completing a component link in the interaction. Hence, after one of the birds completed a component in the sequence, the other bird often did not immediately attend to the new stimulus on its response panel, a situation that resulted in long pauses on the part of both birds. The tacter, especially, sometimes missed the S^{Gcr} completely or received it only after a long pause since its last matching response.

Condition 3

Condition 3 was maintained for 19 days. It replicated Condition 1 except that the birds were unable to see each other. The tacter was satiated on alternate days, as before. As Table 2 reveals, the tacter continued to match for the first 6 satiated days, but on the 7th, 9th, and 10th sessions of the satiated condition (i.e., Days 48, 52, and 54, respectively) the tacter stopped matching. In fact, the tacter spent Sessions 9 and 10 literally sitting on the floor of its chamber, facing away from the response panel. At this point we discontinued Condition 3.

Some topographical observations regarding the first 6 satiated days of Condition 3 are noteworthy, however. The emotional behavior displayed by the tacter during the satiated condition in Condition 1 was absent in Condition 3, and responses to the inoperative food and water keys in the presence of the flashing S^{Gcr} were few. Typically, after matching a color to the sample

[2] A question might arise at this point as to why we did not simply discontinue the presentation of the S^{Gcr} for Condition 2, rather than insert the opaque barrier between the two birds. Our reasoning was as follows: At the end of Condition 1, the S^{Gcr} was a powerful reinforcing consequence for the tacter, but so was the presentation of the mander's "Thank you" floor light, which the tacter could see. In addition, the mander's response directed toward the "Thank you" key was a powerful reinforcer for the tacter. The "Thank you" key and the mander's responses presumably became reinforcing through temporal pairings with the S^{Gcr}. Hence, we felt it would be experimentally less cluttered simply to insert an opaque barrier and thus control for all the stimuli in the adjacent chamber. This left the S^{Gcr} as the only consequence of the tacter's matching response.

letter, the tacter paused, noticed the S^{Gcr} when it began to flash, and attended to it until the flashing light terminated. The tacts emitted in these sessions, although few in number, satisfy the conditions for pure tacting—they were emitted in the absence of either deprivation or aversive threatening behavior from the mander. Tacting extinguished in this phase either because the S^{Gcr} lost its effectiveness or because stimuli from the mander as an audience and source of motivation were necessary for continued tacting (or both). To discover whether tacting would reappear if the opaque barrier was removed, we reinstated the conditions of Condition 1 for 10 days.

Condition 4

Condition 4 consisted of 10 ABAB sessions (with tacter deprived and satiated in alternate sessions). As revealed in Table 2, accurate tacts were again emitted by the tacter in the satiated condition. The visible presence of the mander revived the tacter's matching behavior. As in Condition 1, the tacter's accuracy between A (deprived) and B (satiated) conditions did not differ significantly by statistical test (A, 94% correct; B, 88% correct). However, the frequency of matching responses emitted by the tacter did differ significantly between conditions (mean number of responses emitted for each session: A, 53.4; B, 6.2; $p < .001$). These observations substantiate Catania's (1979, p. 237) view that whereas the audience does not play a part in defining the tact or in determining its topography, it does play a role in maintaining the tact's strength, although it is not sufficient to maintain the tact indefinitely. It is a *supplementary variable* that can only enhance a response that has other primary sources of strength (MacCorquodale, 1969, pp. 838–839; Skinner, 1957, p. 181).

Discussion

This experiment demonstrates that pigeons can be conditioned to "tact." This finding adds a new feature to the burgeoning domain of "interanimal symbolic communication" and generates some provocative extensions. It is interesting to speculate on whether an S^{Gcr} paired with more than two unconditioned reinforcers might be able to maintain a greater frequency of responding (i.e., tacting) in the satiated condition, especially in the "over the phone" condition of Condition 3; we used the weakest S^{Gcr} possible (namely, a neutral stimulus paired with only two reinforcers, food and water). Additional reinforcers could have been paired with the flashing light to produce an S^{Gcr} with possibly a more potent reinforcing effect. If later-evolved organisms were conditioned in this manner, more durable and more complex performances might be maintained. Variations of the procedures are possible. One might try a more gradual fading or degrading of the tacter's view of the mander to determine whether tacting could ultimately be maintained without an audience in view. One might also test whether the mander, when fully visible, is sufficient to maintain tacting even if the S^{Gcr} is omitted entirely. Finally, it would be interesting to ascertain whether a "new" matching response (e.g., G for green) could be conditioned in a pigeon (or, perhaps, a chimpanzee) when the organism receives only an S^{Gcr} for correct responding and is satiated for the unconditioned reinforcers with which the S^{Gcr} was originally paired.

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