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VOCALIZATIONS OF WHITE CARNEAUX PIGEONS DURING EXPERIMENTS ON SCHEDULE-INDUCED AGGRESSION[1]

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Two types of vocalizations of White Carneaux pigeons were identified in experiments on schedule-induced aggression and were given pictorial representation in sound spectrograms. Characteristics of these vocalizations are examined in the context of previous descriptions of vocalizations of several varieties of pigeons during aggressive and sexual encounters in naturalistic settings. These earlier descriptions portrayed vocalizations with mnemonic phrases and the symbols of dictionary pronunciation. Data are presented that indicate that the analysis of social encounters between pigeons during schedule-induced aggression may be aided by employing these and other vocalizations as dependent variables.

In most experiments on schedule-induced aggression, contacts between pigeons are automatically detected by the closure of a switch mounted on the target-pigeon's restraining device (*e.g.*, Azrin, Hutchinson, and Hake, 1966). The validity of switch closures as a measure of aggression usually is supported by descriptions of the complex behavioral matrix in which the switch closures occur. Azrin *et al.* (1966) provided the first description and it has been frequently cited (*e.g.*, Gentry, 1968) as representative of the behavior observed in succeeding experiments:

> Visual observation revealed that attack consisted of strong pecks at the throat and head of the target bird, especially around the eyes. The feathers of the target bird were often pulled out and the skin bruised. The attack was often preceded by a brief period of pacing in front of the wall on which the response key was mounted. Occasionally the pecking attack was preceded by striking movements of the wing or by a slow swaying approach to the target bird with the head lowered. Frequently, the attack was preceded and accompanied by a deep-throated sound. [Azrin *et al.*, 1966, pp. 194-195]

Descriptions of this behavioral matrix by other authors usually have noted vocalizations by the attacking pigeon that are often described as "coos" (*e.g.*, Knutson, 1970, p. 226).

There seems little doubt that distinct vocalizations accompany a variety of social encounters in pigeons (Craig, 1911; Goodwin, 1956*a*, *b;* Levi, 1963, p. 376) and other birds (Hinde, 1969; Thorpe, 1961), and that they often are interpreted by observers as indices of a specific "motivational" state. Because the terms "deep-throated sound" and "coos" are not precise, it is difficult to know whether they describe one type of vocalization in schedule-induced aggression experiments or whether a variety of distinct vocalizations occur that are not adequately differentiated by this terminology.

Attempts to provide objective descriptions of the vocalizations of pigeons have employed the symbols of dictionary pronunciation (*e.g.*, Goodwin, 1956*a*), musical notation (*e.g.*, Craig, 1911), and mnemonic phrases (*e.g.*, Fabricius and Jansson, 1963; Levi, 1963, p. 376). Sound spectrograms, which give a graphic representation of frequency, amplitude, and duration of a sound, provide less-subjective descriptions

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of bird vocalizations than the other methods (Thorpe and Lade, 1961), and are employed in the present paper to present an objective description of two distinct vocalizations heard repeatedly during experiments on schedule-induced aggression in this laboratory (*e.g.*, Dove, Rashotte, and Katz, 1974; Rashotte, Dove, and Looney, 1974). These descriptions are discussed in terms of previous descriptions of pigeons' vocalizations in natural social settings and some data are presented that illustrate the potential usefulness of vocalizations as a dependent variable in experiments on schedule-induced aggression in pigeons.

METHOD

Subjects

Six male White Carneaux pigeons, between 1 and 3 yr of age, obtained from the Palmetto Pigeon Plant, Sumter, South Carolina, were maintained at 80% of their free-feeding weights and were individually housed in wire-mesh cages under constant fluorescent illumination. Water and health grit were continuously available in the home cages. Before the procedures described below, four of the pigeons had pecked a response key in the presence of a taxidermically stuffed pigeon for several sessions and one of the four pigeons also had received food for pecking on the stuffed pigeon.

Apparatus

Experimental sessions were conducted in a Foringer Model 1104 test chamber painted flat black. The inside dimensions of the chamber were 40 by 37.5 by 39.4 cm and it was housed within a slightly larger wooden box. The chamber was illuminated by a 25-W, 115-V ac frosted incandescent bulb located in a corner of the ceiling behind sandblasted clear acrylic. An exhaust fan provided ventilation and white noise provided continuous masking. The total noise at the center of the chamber measured 78 dB SPL. The top of the box enclosing the chamber was cut away and a closed-circuit television camera was mounted above the opening to allow constant visual monitoring of the chamber from an adjacent room. A Sony F-98 cardioid microphone behind one wall of the test chamber permitted audio monitoring, and permanent audio-visual records of events in the chamber were made on a Sony AV3650 Videocorder. Video recordings could be replayed in slow-motion when detailed analysis was desired.

Three adjacent walls of the test chamber had features important to the observations reported here. A solenoid-operated grain hopper behind one wall could present grain in an opening midway along the wall and slightly above the chamber floor. A spring-loaded treadle was mounted on the opposite wall. It protruded 5.7 cm into the chamber 4.4 cm above the floor and extended the entire length of the wall. Depressions of the treadle with at least 0.35 N force caused a microswitch on the treadle to close and, through relay circuitry in an adjoining room, sometimes caused the grain hopper to be raised for a fixed period of time. Finally, the wall adjoining the two walls described above contained a 14 by 24.1 cm Eastman Kodak glass rear-projection screen mounted in a spring-loaded microswitch assembly. Contacts on this screen of 0.50 to 0.75 N or greater force were automatically recorded on digital counters. A slightly larger-than-life-size color slide image of a White Carneaux pigeon was normally projected onto this screen throughout the experimental session. The image was projected by a Kodak Carousel 750H projector with an f 3.5 lens and a 300-W ELH lamp. The lamp-intensity switch on the projector was placed on the low setting.

An Uher "Royal 10,000" model audio tape recorder with tape speed set at 7.5 ips was used to record vocalizations and to replay them for sound spectrographic analysis. Recordings were made with a Shure Model 566 microphone located behind the wall on which the grain hopper was mounted.

Sound spectrograms of selected vocalizations were made on a Kay Electric Company Sound Spectrograph, Model 6061A. Sound spectrograms provide a graphic representation of the frequency, amplitude, and duration of a sound and they have been used extensively in the analysis of animal vocalizations (Hinde, 1969; Thorpe and Lade, 1961). Spectrograms are made "off-line" by replaying a recorded sound through the spectrograph. In graphic representation, the frequencies that comprise the sound are displayed along the y-axis as a function of time on the x-axis and the amplitude of the sound is approximately represented in the depth of shading. Band pass filters allow the graphic display to emphasize either general variation as a function of time or harmonic structure, and the frequency range displayed in the spectrogram can be selected to enhance resolution of the graphic display. In the present work, a 3-kHz frequency range was employed because it included virtually all of the frequencies that made up the pigeon vocalizations and allowed relatively good resolution of the characteristics of these rather low-frequency vocalizations. A moderate-width (125 Hz) band pass filter was employed to display the harmonic structure of the vocalizations. Additional details of the method and interpretation of spectographic analysis can be found in Thorpe and Lade (1961) and Marler (1969).

Procedure

With the rear-projection screen illuminated clear white through a neutral density filter (N. D. 0.80), brief access to grain was used to "shape" treadle pressing. Over a period of several months, treadle pressing was reinforced on a variety of schedules with a pigeon image projected on the screen. One schedule required a fixed number of treadle presses per grain presentation (FR), another required a single press following a fixed period of time (FI), and the third was a multiple schedule in which the presence of white noise signalled that each of 10 successive treadle presses would be followed by grain and the absence of white noise signalled a 5-min period of extinction. The FR schedule was varied between FR 1 and FR 60 and the FI schedule was varied between FI 1-min and FI 5-min. Experimental sessions typically lasted for 1 hr and involved as many as 60 presentations of grain.

Events in the experimental chamber were constantly monitored on closed-circuit television and many sessions were video-taped in an attempt to arrive at a workable system for describing the various behaviors that experimental pigeons directed toward the rear-projected pigeon image. Two outcomes of this work are presented in this paper.

First, two distinct vocalizations were frequently identified: one, termed "Vocal A", occurred predominantly during aggressive periods while the session was in progress. The other, "Vocal B", occurred primarily before and after the session while the test chamber was dark. The Uher audio-recording system was added to the experimental set-up so that these two vocalizations could be recorded with sufficient quality for sound spectrographic analysis. It proved necessary to record with the ventilating fan and white noise turned off. A large sample of vocalizations was obtained during the sessions and in 5-min periods before and after the sessions when the test chamber was dark. Several good-quality instances of each type of vocalization were converted to sound spectrograms.

Second, an example of the potential usefulness of vocalizations as a dependent variable in experiments on schedule-induced aggression was recorded on video-tape and subjected to a descriptive analysis. When Pigeon 4357 had treadle pressed on FR 60 for 14 sessions in the presence of a projected pigeon image, the image was replaced with a lighted blank screen for one session and the pigeon image was returned in the following session. Video-tape records of various parts of these sessions were analyzed through regular-speed and slow-motion replays to quantify the proportion of time in which specific responses were performed. Using the categories of Fabricius and Jansson (1963), responses were classified into two general categories: those that involved contact with the screen, and those that did not. The responses were not necessarily mutually exclusive. The specific responses in the Contact category to be reported are:

Screen Charge: slams into the rear-projection screen with head or chest.
Head Pecks: pecks at the head of the projected pigeon image.
Off-Bird Peck: pecks on the screen but off the pigeon image.

Noncontact responses included:

Bow-Screen Action: repeatedly bows head deeply toward ground while positioned in front of screen.
Bow-Circle Action: repeatedly bows head deeply while locomoting in front of screen, often turning completely in a circle.
Vocal A and Vocal B: Figures 1 and 2 and related text below describe these vocalizations.
Displacement: makes quick pecks to own scapulars.
Pause: no distinct screen-directed behavior.

RESULTS AND DISCUSSION

Five of the six pigeons showed distinct instances of defensive and aggressive responses in the first few sessions with the pigeon image present (*e.g.*, wing-strikes directed towards the screen; bowing and "cooing" while turning in a circle in front of the screen; charging into the screen; pecking on the head of the pigeon image). A characteristic temporal distribution of these responses in each session quickly developed: they were likely to occur in the first minute or two of each session when the pigeon image was first turned on and before treadle pressing began, and they also occurred shortly after the pigeon ate from the grain hopper. Schedule-induced aggression is characterized by postfeeding attack (Azrin *et al.*, 1966; Gentry, 1968).

Figures 1 and 2 show sound spectrograms of two kinds of vocalizations by two birds. The panels labelled "Vocal A" show instances of the vocalization that often accompanied the defensive and aggressive responses described above. These vocalizations appear to approximate several descriptions of vocalizations during the bow-coo reaction (*i.e.*, the "display-coo", Goodwin, 1956*a*). This is said to be an integral component of sexual and aggressive encounters (Fabricius and Jansson, 1963). Previous descriptions of this vocalization include "wang-wang-ruck-ho" (proposed by Heinroth, cited in Fabricius and Jansson, 1963), "Ŏŏ-rŏŏ-k'tŏŏ-cŏŏ" (Goodwin, 1956*a*), and "a complicated bubbling sound" (Levi, 1963, p. 376). In the present experiments, this vocalization occurred reliably while the pigeon was bowing and circling in the region of the target pigeon, and sometimes during episodes of wing-striking at the target, during occasional sharp swipes with the beak at the target preceding contact, and during periods of vigorous contact with the target pigeon, particularly in its head region. We have heard both single utterances of Vocal A and repetitions of Vocal A at relatively short and regular intervals for prolonged periods. Levi states that this vocalization "is associated principally with strutting or with fighting" (Levi, 1963, p. 376; see also Åkerman, 1966) and it is often noted in both territorial defense and precopulatory activity (*e.g.*, Fabricius and Jansson, 1963).

The figures show that each utterance of Vocal A consists primarily of a narrow, low-frequency range of energy (0.0 to 0.5 kHz), with the frequency range increasing to about 2.0 kHz for brief periods in each utterance. Several distinctive characteristics of Vocal A are evident between the birds shown in Figures 1 and 2. The most obvious is that the duration of

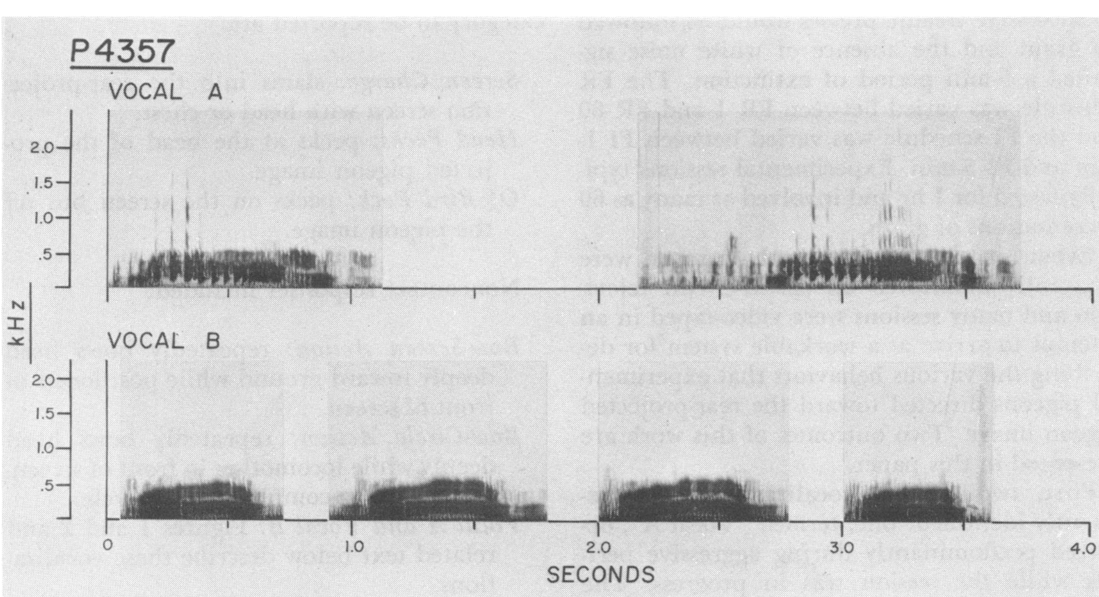

Fig. 1. Sound spectrograms of two types of vocalization in Pigeon 4357. The duration of each vocalization can be read from the abscissa, the frequencies of the components of the vocalization can be read along the ordinate, and amplitude is approximately represented by depth of shading.

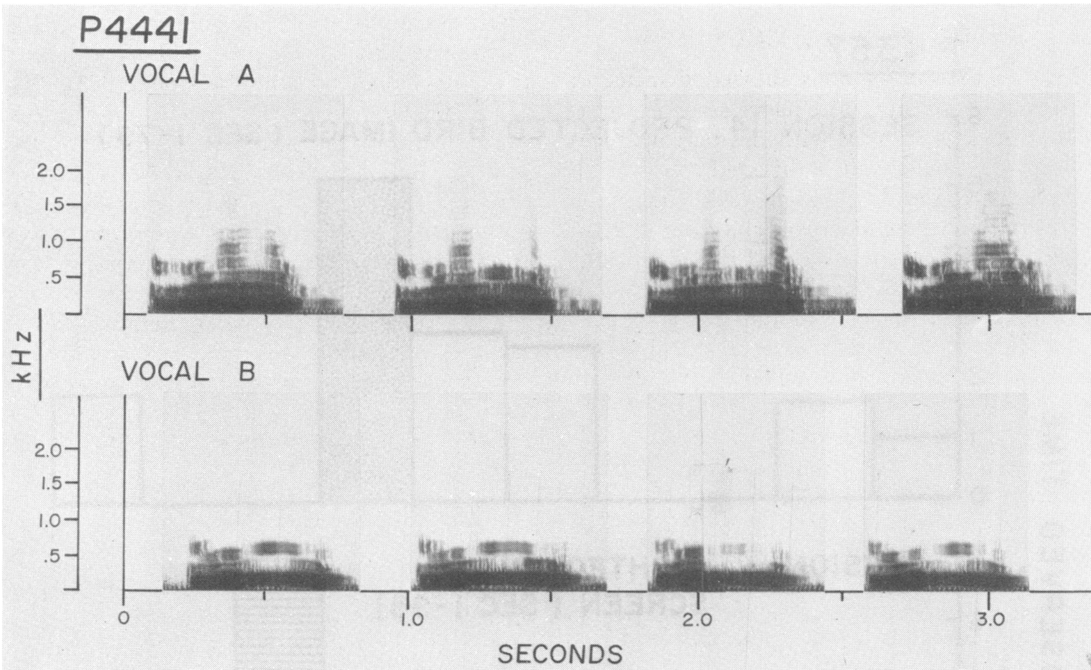

Fig. 2. Sound spectrograms of two types of vocalization in Pigeon 4441.

each utterance and the inter-utterance intervals are longer in Pigeon 4357 than in Pigeon 4441. Perhaps it is less obvious that Vocal A for Pigeon 4441 is characterized primarily by a smooth pattern of energy indicating a high rate of opening and closing the syrinx, whereas the Vocal A utterances of Pigeon 4357 are distinguished by relatively low-frequency pulsing of the syrinx at the beginning and end of each utterance. This pulsing pattern can be seen readily by contrasting the relatively smooth pattern of energy between about 0.60 and 0.75 sec in the first utterance of Vocal A in Figure 1 with the interrupted pattern of vertical striations earlier and later in that utterance. It seems likely that the differences in Vocal A shown in Figures 1 and 2 reflect differences within a single class of vocalizations. Levi has noted that this "bubbling sound" vocalization, which he termed "crowing", differs ". . . between cocks and hens, between breeds, and individual birds, but [is] fairly constant in articulation for any given bird" (Levi, 1963, p. 376).

Vocal B in the figures appears to be an instance of the "advertising coo" that occurs during nest demonstration (Fabricius and Jansson, 1963; Goodwin, 1956*a;* Levi, 1963, p. 376). Goodwin (1956*a,* p. 64) noted that it also occurs when the pigeon is ready to feed well-grown young and when tame specimens that are breeding are waiting to be fed by their owners. Vocal B has been described previously as "Ōôrh" or "Oh-ōō-ōōr" (Goodwin, 1956*a*), "aoo, aoo, aoo" (Fabricius and Jansson, 1963), and as a "true" coo by Levi, who provides a more complete description in the following words: ". . . [a] moaning or mournful sound, often rising and falling, usually uttered while the bird is in its nest or on a perch. It is the "Whooo-a" by which one bird attempts to call the attention of its mate" [Levi, 1963, p. 376].

In our experiments, Vocal B occurred primarily before and after the experimental session, when the chamber was dark, and it occurred less reliably than Vocal A. It was a regular (about 1 Hz), predominantly low-frequency (maximum frequency ≈ 0.75 kHz) vocalization that had a distinct rise-and-fall quality, as shown both in frequency and intensity in the spectrograms. Differences between pigeons in the spectrograms of Vocal B seem less pronounced than in the case of Vocal A. Frequently, we have heard long trains of utterances of Vocal B that increased in loudness as the train progressed and ended with a final utterance similar to that described here as Vocal A. Trains longer than 1 min in length were not uncommon.

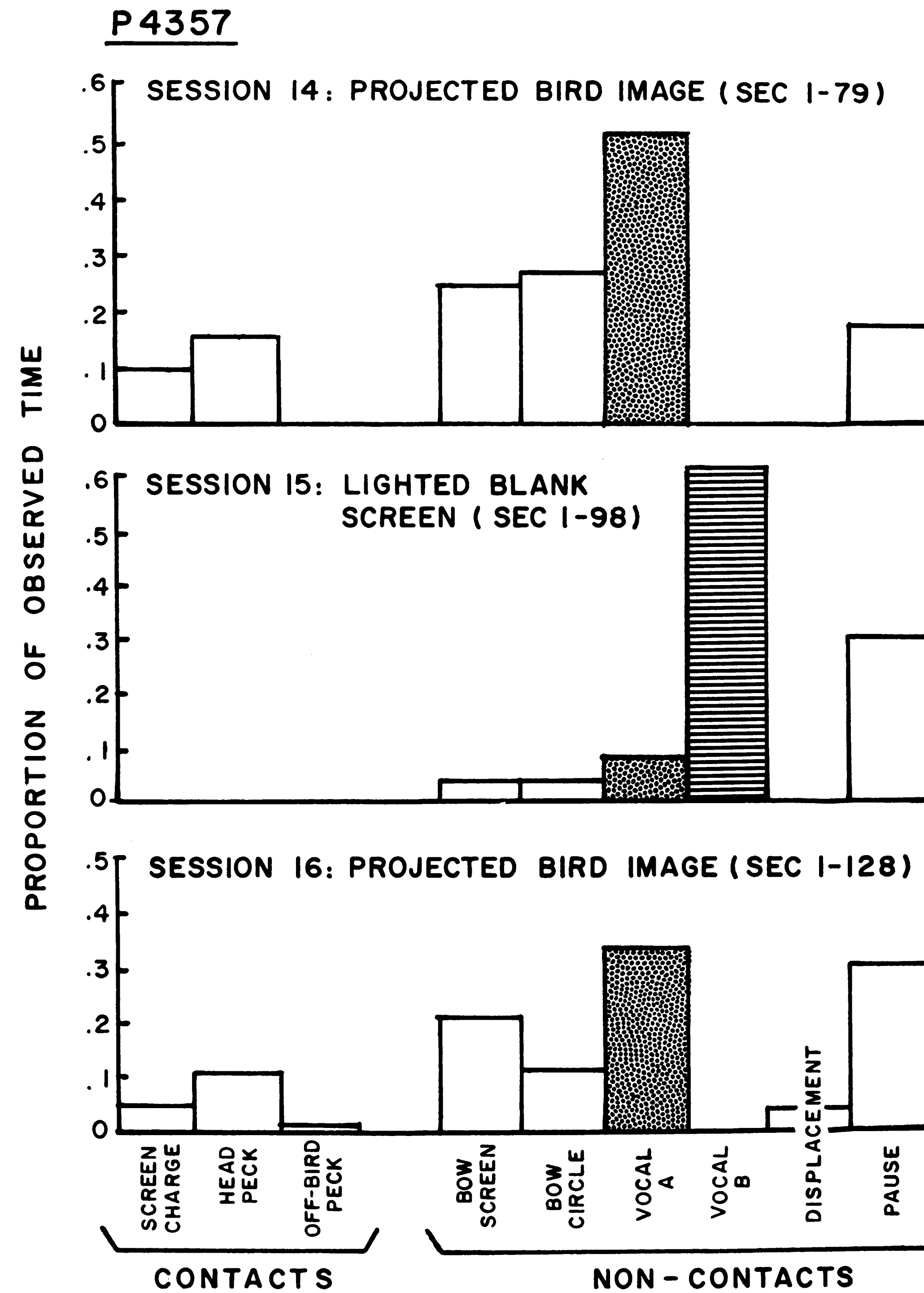

Fig. 3. Pigeon 4357: proportion of the first 1 to 2 min of Sessions 14, 15, and 16 spent in various contact and noncontact responses. In Sessions 14 and 16, an image of a pigeon was projected on a screen in the chamber. In Session 15, the screen was lighted but blank. The number of seconds in each observation period is shown for each of the sessions.

Figure 3 summarizes a pigeon's screen-directed responses in the first minutes of the three successive sessions in which the image on the screen was manipulated. The observation period in each of these sessions was terminated by the first treadle press and the proportion of each observation period spent in the contact and noncontact response categories described earlier was determined by slow-motion replays of video-tapes. The responses shown are representative of responses later in each of the sessions.

Figure 3 shows that when the pigeon image was present in Sessions 14 and 16, screen contacts occurred, and bowing and Vocal A were prominent noncontact responses. In Session 15, when the pigeon image was absent, contacts did not occur, bowing and Vocal A were markedly reduced, and Vocal B was the predominant behavior. These data suggest that vocalizations may provide significant information about social interactions in these experiments that cannot be gained from the traditional contact measure. In particular, the present data show aggressive vocalizations when the pigeon image was present (Vocal A of Figures 1 and 2) and vocalizations similar to those reported when a pigeon calls to its mate when the pigeon image was absent (Vocal B). The simple point made by these data is that analysis of vocalizations in experiments on schedule-induced aggression may provide useful information about the pigeon's perception of the experimental conditions, and thereby may lead to a better understanding of the dynamics of the social encounters studied in these experiments.

A principal suggestion of the present paper is that the vocalizations of pigeons in experiments on schedule-induced aggression may be a useful adjunct to the traditional dependent variables, which are based on switch closures. The combination of verbal and spectrographic description of two distinct vocalizations in this paper should be sufficient to allow other investigators to monitor their experiments for similar vocalizations. It is our experience that human observers can readily identify these two calls under normal experimental conditions (*i.e.*, white noise, masking fan on) when monitored via a loudspeaker system. However, it should be noted that our experiments have employed inanimate targets and that it may be more difficult to determine which bird is producing the vocalizations when a live target is employed. A solution to this problem is to add visual monitoring of events in the experimental chamber.

The present paper has identified two classes of vocalizations of White Carneaux pigeons during experiments on schedule-induced aggression. A third class of vocalization has been identified in *Columba livia* as a distress or warning call. It has been described as a "short grunt" (Levi, 1963, p. 376), "wao" (Fabricius and Jansson, 1963), and as "Ŏŏrh!" or "Ĕĕrh!" (Goodwin, 1956*a*). Goodwin comments that the call is very similar in all pigeons and is given at the sight of distant predators and in situations where annoyance, discomfort, or indecision occurs. We have not noted distinct instances of this type of vocalization in our experiments. Future observations may document the presence of this or other vocalizations. At present, it seems that the differences between pigeons in Vocal A or Vocal B shown in Figures 1 and 2 are due to individual differences. However, it is conceivable that our classification of pigeon vocalizations as Vocal A and B may ignore finer discriminations that may become evident in future spectrographic analysis. It would be particularly interesting if, for example, subclasses of what we have termed Vocal A occur under certain experimental conditions but not others (*e.g.*, in the presence of targets with certain characteristics).

Finally, it may be profitable to employ tape-recorded pigeon vocalizations as an independent variable in experiments on schedule-induced aggression. This strategy would permit investigation of the effects of specific vocalizations emanating from a variety of visual targets on the attacking pigeon's behavior. Experiments with other birds indicate that vocalizations are strong sources of behavioral control in some social situations (*e.g.*, Falls, 1969; Thorpe, 1972). When vocalizations are employed as an independent variable, sound spectrograms can provide objective descriptions of the stimulus materials employed.

REFERENCES

Åkerman, B. Behavioural effects of stimulation in the forebrain of the pigeon. I. Reproductive behaviour. *Behaviour*, 1966, **26**, 323-338.

Azrin, N., Hutchinson, R. R., and Hake, D. F. Extinction-induced aggression. *Journal of the Experimental Analysis of Behavior*, 1966, **9**, 191-204.

Craig, W. The expression of emotion in the pigeons. II. The mourning dove (*Zenaidura Macroura* Linn.), *Auk,* 1911, XXVIII, 398-407.

Dove, L. D., Rashotte, M. E., and Katz, H. N. Development and maintenance of attack in pigeons during variable-interval reinforcement of key pecking. *Journal of the Experimental Analysis of Behavior,* 1974, **21,** 463-469.

Fabricius, E. and Jansson, A. Laboratory observations on the reproductive behaviour of the pigeon (*Columba livia*) during the pre-incubation phase of the reproductive cycle. *Animal Behaviour,* 1963, **11,** 534-547.

Falls, J. B. Functions of territorial song in the white-throated sparrow. In R. A. Hinde (Ed.), *Bird vocalizations: their relation to current problems in biology and psychology.* Cambridge: Cambridge University Press, 1969. Pp. 207-232.

Gentry, W. D. Fixed-ratio schedule-induced aggression. *Journal of the Experimental Analysis of Behavior,* 1968, **11,** 813-817.

Goodwin, D. Observations of the voice and some displays of certain pigeons. *Avicultural Magazine,* 1956, **62,** 62-70. (*a*)

Goodwin, D. The significance of some behaviour patterns of pigeons. *Bird Study,* 1956, **3,** 25-37. (*b*)

Hinde, R. A. (Ed.). *Bird vocalizations: their relation to current problems in biology and psychology.* Cambridge: Cambridge University Press, 1969.

Knutson, J. F. Aggression during the fixed-ratio and extinction components of a multiple schedule of reinforcement. *Journal of the Experimental Analysis of Behavior,* 1970, **13,** 221-231.

Levi, W. M. *The pigeon.* Sumter, S.C.: Levi Publishing Company, Inc., 1963.

Marler, P. Tonal quality of bird sounds. In R. A. Hinde (Ed.). *Bird vocalizations: their relation to current problems in biology and psychology.* Cambridge: Cambridge University Press, 1969. Pp. 5-18.

Rashotte, M. E., Dove, L. D., and Looney, T. A. Absence of shock-elicited aggression in pigeons. *Journal of the Experimental Analysis of Behavior,* 1974, **21,** 267-275.

Thorpe, W. H. and Lade, B. The songs of some families of the Passeriformes. I. Introduction: the analysis of bird songs and their expression in graphic notation. *Ibis,* 1961, **103,** 231-245. (*a*)

Thorpe, W. H. *Bird-song: the biology of vocal communication and expression in birds.* Cambridge: Cambridge University Press, 1961. (*b*)

Thorpe, W. H. Vocal communication in birds. In R. A. Hinde (Ed.), *Non-verbal communication.* Cambridge: Cambridge University Press, 1972. Pp. 153-175.

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