Noise-induced changes in calls of the Japanese quail*

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Increasing ambient noise level causes male quail to (1) raise the intensity of individual separation crows, (2) increase the rate of crowing, and (3) increase bout length. Comparison between Japanese quail and human beings suggests that differences in response to noise are related to the type of signal system used by each species.

The short-term adaptations that help an animal to communicate in a noisy environment have thus far been studied only in man. A comparative approach to the problem of communication in a noisy environment should reveal species differences that are related to the signal system being utilized.

Male Japanese quail, *Coturnix coturnix japonica*, like other quail species, emit separation calls when visually and acoustically isolated from the female quail with which they have paired (Ellis & Stokes, 1966; Stokes, 1967; Potash, in press). In Japanese quail, the separation call or "crow" is a three-syllable call approximately 0.8 sec in duration and typically covering a range of frequencies from 500 to 6,000 Hz (Potash, in press). Sound spectographic analysis indicates that the separation crow is identical to the crow of the unmated male (Potash, in press). The context in which separation crowing occurs suggests that its function is to help reestablish contact between separated members of a pair (Potash, in press). Previous work by the author has demonstrated that increasing the ambient noise level results in an increase in both the rate of separation crowing and the number of crows per bout (Potash, in press). The present study was undertaken to determine whether Japanese quail also increase the intensity of individual separation crows. Comparable work done with human beings indicates that people prolong syllables (Kryter, 1970), reduce speaking rate (Kryter, 1970), and speak with greater intensity (Kryter, 1970) when the ambient noise level ("white" noise) increases.

SUBJECT SELECTION

Prior to testing, each of 14 pairs of male and female Japanese quail, 1 year of age, was placed in a hardware cloth cage (48 cm long x 36 cm wide x 25 cm high) contained inside a large acoustic chamber (inside dimensions, 89 cm long x 66 cm wide x 152 cm high). A 16-h-light/8-h-dark cycle of illumination was maintained to keep the animals in breeding condition. The animals were handled for 7 consecutive days to habituate them to handling. The animals were observed through a one-way mirror and were acoustically monitored. Only quail that exhibited a good pair bond, as judged by the lack of threat displays and aggressive behavior or avoidance of one another, by the male offering food to the female (tidbitting), and by daily egg laying, were used in the experiment. Seven pairs exhibited good pair bonds by these criteria. In addition, the seven potential Ss were tested on the seventh day to insure a minimum operant crowing level. Five of the males had crowing rates in excess of 15 crows per 15 min when separated from the female. These five males and their mates were used as Ss.

METHOD

Throughout testing, Ss were housed in the acoustic chambers, one pair per chamber.

Measurements of ambient noise level were made by placing the microphone of a Dawe sound-level meter in the center of the housing cage at approximately the quail's head level. Measurements were made with the A-scale, which is approximately linear within the range of frequencies covered by the separation crow but is progressively weighted against frequencies below 500 Hz, to which at least some avian species are relatively insensitive (Konishi, 1970). Three noise conditions were used: (1) normal ambient noise level (AN)—35 dB(A); (2) low white-noise level (LWN)—45 dB(A); (3) high white-noise level (HWN)—60 dB(A).

To produce the white noise, the output from a General Radio Company random noise generator, filtered below 500 Hz and above 5,000 Hz using a Breul and Kjar Model 124 graphic spectrum equalizer filter, was amplified and played through a 20.3-cm Marsland Princess speaker placed 76 cm above the floor of the cage. A Sony F 96 omnidirectional microphone placed 127 cm above and centered over the cage was used to record vocalizations. The distance between microphone and chamber floor was made large relative to the cage dimensions to minimize the effect of the animal's movement upon signal intensity at the microphone. Measurements made by playing white noise through a Marsland Princess 20.3-cm speaker placed in the four corners and center of the area occupied by the housing cage at the approximate height of the quail's head indicate a positional variation in intensity of less than 2 dB. Since the quail raises its head above its body when crowing, it seems doubtful that the crow is appreciably directional.

Two days elapsed between preliminary screening and the experiment. In the experiment, each S was tested with the three noise conditions, one noise condition per day, the order of exposure being varied. In the white-noise condition, the noise was maintained for 3 h prior to the test period as well as during the test period and for 30 min after it. In the test period itself, the female was removed from the chamber for 15 min and the vocalizations of the male were tape recorded with a Sony 230 tape recorder for later analysis. The gain on the tape recorde;was kept constant throughout the experiment, and the tape-recorder/microphone system was checked daily by recording 75-dB(A) white .noise and then displaying the amplitude on a Tectronix Type 564 B storage oscilloscope. Sessions were recorded on Scotch 203 Dynarange magnetic tape.

The intensity of individual crows was analyzed by playing the tape at half speed into the oscilloscope and recording the maximum voltage deflection for the third and most intense part of the crow. In order to estimate te average decibel level of the crows under the three conditions, a crow was replayed using a Sony 230 tape recorder and Marsland Princess speaker. A Dawe sound-level meter set at fast response and positioned so that its microphone was next to the Sony F 96 microphone indicated sound level during playback. The intensity of the crow was adjusted in 6-dB steps, the crow being played back twice at 52, 58, 64, 70, 76, 82, and 88 dB(A) for rerecording, using the previously described recording system. The average peak voltage deflection at each decibel reading was used to plot voltage deflection as a function of decibel level. The resulting graph was used to estimate the decibel level that corresponded to the average voltage

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Table 1
Effect of Different Noise Conditions on Separation Crowing*

	Average Voltage Deflection (0.2 V Per Unit)			Rate of Crowing (Crows Per Minute)			Average Number of Crows Per Bout		
	AN	LWN	HWN	AN	LWN	HWN	AN	LWN	HWN
	3.75	9.72	12.64	1.67	2.37	3.13	1.31	1.94	1.88
	2.42	6.77	13.93	7.21	8.43	8.80	2.41	2.53	2.61
	2.15	3.88	4.26	3.72	5.90	6.32	3.13	3.95	3.58
	1.77	5.28	11.06	2.90	4.19	5.56	1.91	2.10	2.86
	4.47	7.08	8.78	0.80	2.57	2.63	1.83	2.85	3.17
Mean	2.91	6.55	10.13	3.26	4.69	5.29	2.12	2.67	2.82
	$F = 15.27$, $p < .01$			$F = 36.27$, $p < .01$			$F = 7.67$, $p < .05$		

**Each row contains data from one S*

for each condition for each S. The decibel levels were then averaged over Ss for each condition to produce the estimate cited. The two crows were also recorded in the HWN condition [54 dB(A) at the position of the microphone] for each of the 6-dB steps to see if the white noise affected intensity measurement on the oscilloscope. The white noise produced a small deflection of only 0.2 V, and no appreciable additive affect was evidenced (less than .04 V).

The data were analyzed using a one-way analysis of variance with repeated measures on the same elements.

RESULTS AND DISCUSSION

The results in Table 1 show that male Japanese quail, like human beings, raise the intensity of their acoustic signal when subjected to a relatively noisy environment ($F = 15.27$, $df = 2/8$, $p < .01$). This kind of adaptation can be utilized in most signal systems where intensity is not part of the coding used in the signal. The average voltage readings for the normal ambient noise, low white noise, and high white noise conditions correspond to 66, 74, and 78 dB(A), respectively. By comparison, human beings raise speech intensity from 3 to 7 dB per 10-dB increase in noise (Kryter, 1970).

The latency between removal of the female and emission of the first crow ranged from 5 to 217 sec. The average latencies for the normal ambient noise, low white noise, and high white noise conditions were 122, 37, and 25 sec, respectively, the latency of separation crowing decreasing with increasing noise level.

The rates of crowing listed in Table 1 were calculated by dividing the total number of crows by the time between onset of the first crow and termination of the recording session. Table 1 indicates that the rate of crowing increases when the noise level increases ($F = 36.27$, $df = 2/8$, $p < .01$). In contrast, people reduce speaking rate and increase syllable duration when the ambient noise level is raised, although the effect of noise on reading or talking rate is not pronounced until high levels are reached (Kryter, 1970). When the signals utilized are complex and nonrepetitive, such as with normal human speech, it may be advantageous to reduce speaking rate and increase syllable duration so that the individual words or linguistic units can be more clearly distinguished. Use of other channels such as vision (gesticulation, facial expression, etc.) is also possible in normal human "face-to-face" conversation. In separation crowing, however, the same signal is being emitted repetitively over potentially large emitter-receiver distances in which emitter and receiver are not typically in visual contact. One of the most common sources of ambient noise—wind—not only increases the background noise level, but also affects the propagation of the acoustic signal itself. A gusty wind may cause peak-to-peak fluctuation in the receiving end of over 20 dB at a 100-m distance from the source (Ingard, 1953; Wiener & Keast, 1959). "Stable" nighttime conditions may result in 5-dB differences (Wiener & Keast, 1959). Laboratory experiments utilizing human listeners under relatively stable propagation conditions indicate that repetition of words results in a modest improvement in their detection equivalent to that produced by raising intensity by about 3 dB (Kryter, 1970; Thwing, 1956). Repetition should be far more effective in nature where conditions of propagation are relatively unstable. Increasing rate of emission should increase the probability that crows occur during favorable intervals for propagation. Fluctuations in the attention of the receiver should also have an effect similar to that of fluctuations in signal strength.

Separation crows occur in temporal groups or bouts with typical intercrow intervals within a bout of 1 sec, though intervals as long as 4 sec sometimes occur. All groups of crows with an intercrow interval of less than 5 sec were counted as being in the same bout. Intercrow intervals were measured by playing the crows into the oscilloscope, using a slow-sweep speed (5 sec/cm). Table 1 shows that the number of crows per bout increases with increasing noise level ($F = 7.67$, $df = 2/8$, $p < .05$). Grouping crows into bouts should increase the probability that successive crows will occur after the receiver's attention has been attracted by initial crows and should allow successive orientation by the receiver to the crows. Increasing the number of crows per bout might be effective for increasing localizability and detectability of the crow.

The adequate stimulus for the changes in separation crowing may be the change from one noise level to another, the ongoing noise itself, the masking effect of ongoing noise on feedback from the quail's own vocalizations, or some combination of the above. The changes in separation crowing occur after 3 h of prior exposure, indicating that the crowing is being influenced by the ongoing ambient noise rather than by the change from one noise level to another. The decreasing latency of calling with increasing noise level suggests a direct effect of ongoing noise, but the masking of faint contact calls (whistle and associated call notes; see Potash, 1970, for a description of this call) and faint tidbitting-like calls that usually precede separation crows may be responsible for decreasing latency of crowing. The finding that deafened ring doves tend to emit longer bouts of perch-cooing than do normal individuals (Konishi & Nottebohm, 1969) suggests that masking is responsible for the increase in bout length.

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