J. Ethol. 11 : 111–116, 1993

Visual and Auditory Cues in Conspecific Discrimination Learning in Bengalese Finches

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Abstract — Four Bengalese finches were trained to discriminate 2 conspecific individuals in an operant chamber. Still visual images and contact calls were simultaneously presented to the subjects and specific ("correct") perching response was reinforced with food. After the birds acquired the discrimination, they received the first test in which visual cues alone, auditory cues alone and combination of the 2 modalities were presented. Visual cues dominantly controlled the discriminative behavior of all birds. Then the subjects received the second test in which mixtures of the visual image of 2 stimulus birds appeared under 3 different auditory conditions, namely, no call, calls of 1 bird and calls of the other bird. Two subjects used the auditory cues when the visual stimulus was a mixture of 2 stimulus birds. These results suggest that the birds used less dominant cues when the dominant cues gave ambiguous information.

Many playback experiments suggest that auditory neighbor recognition occurs in several avian species. There have also been several laboratory experiments demonstrating visual individual discrimination in birds, for example, chickens (Howells & Vine 1940; Candland 1969; Ryan 1982), budgerigars (Brown & Dooling 1992; Trillmich 1976) and pigeons (Poole & Lander 1971; Watanabe & Ito 1991; Watanabe 1992). Previously we reported individual discrimination based on visual cues in Bengalese finches (Watanabe et al. 1993). Bengalese finches generally have a high level of variation in feather coloring and also in contact calls. Thus either the auditory or visual cue may give them information enough to discriminate each other. The present experiments examined cue selection in individual discrimination when both visual and auditory cues were available. We also tried to test which parts of the body control individual discrimination.

Method

Subjects

Two male (birds B4 and B6) and 2 female (birds B1 and B2) Bengalese finches *(Lonchura striata domestica)* of about 90-day-old age were used. The birds did not have any experimental history and lived in individual cages (22 × 15.5 × 30 cm). They were deprived of food for 5 to 8 h before the start of daily training.

Apparatus

The experimental chamber was a plastic grid cage for small birds (25 × 15 × 35.5 cm). Details of the chamber were given in Watanabe et al. (1993). A color TV (21.5 × 15.5 cm, National TH11-S71) and a speaker (YAMAHA, MS101) were attached behind the cage. There were 3 perches in the chamber at distances of 10, 18 and 26 cm from the TV screen respec-

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tively. The first perch was a response perch and the second was an observing perch. A photo-sensor detected perching response. There was a food magazine between the screen and the first perch. The food magazine contained mixed seeds for reinforcement.

The experimental chamber was placed in a shield room. A microcomputer (Sanyo Wavy 70 FDM) was used to arrange the experiment.

Stimulus

Visual stimuli were still images of 2 Bengalese finches from another laboratory. One (bird A) was male and had a mixture of dark brown and white feathers. He had dark brown feathers on his breast, rump and cheek. His crown was white. The color of his beak was also white. The other bird (B) was female with dark brown feathers restricted to the dorsal part of the body. Her breast, belly and tail were white. The upper beak was white. Still video images of stimulus birds were taken using a floppy disk camera (Canon Q-PIC) and the images were displayed on the TV screen by a floppy disk player (Konica KR400). Eight different frames of each bird appeared during discriminative training. Chimera stimuli were created by a computer (AMIGA 2500) and were recorded on a floppy disk. Brightness of these stimuli was 3500 cd/m^2.

Contact calls of the 2 stimulus birds were recorded by a MIDI digital sampler (AKAI, S950) and edited with a Macintosh (SE30). The sampler produced auditory stimulus through an auditory signal processing interface (BIT2, MIDI Saurus) attached to a computer. As shown in Figure 1, the duration of the calls was approximately 200 msec. The maximun intensity of calls A and B were 54dB and 48dB, respectively, at the position of the bird's head at the observing perch. These calls were repeated 3 times during a 3 s stimulus period. Time between the calls was 700 msec – 1100 msec. Eight different records were presented during discriminative training.

Procedure

After adaptation to a feeder, each subject was trained to stay on the observing perch for more than 1 s before it jumped to the response perch to get reinforcement. During this period, no visual nor auditory stimuli were presented. Then the subjects were trained on a GO-NOGO type discrimination. Bird A was the stimulus associated with food reinforcement (S+) while bird B was not associated with reinforcement (S−). The subjects had to perch on the observing perch for 2 s, before a stimulus was presented. Video images appeared on the TV screen and simultaneously the contact call of the stimulus birds was played back. If the stimulus was S+, flying to the response perch within 3 s was reinforced by a 5 s presentation of the food hopper. An intertrial interval then started. Response for S− within 3 s resulted in a 15 s time out followed by the intertrial interval. If no response occurred for 3 s for S− the intertrial interval also started. The following correction procedure was employed. No response for S+ or occurrence of response for S− resulted in presentation of the same stimulus until the subject emitted response to S+ or withheld response for S−. GO response to S+ on the correction trial caused a brief (0.5 s)

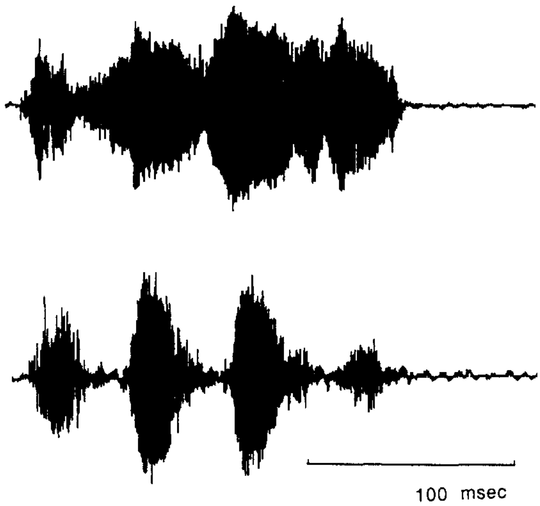

Fig. 1. Samples of temporal power patterns of training stimuli. Upper panel: S+ call, Lower panel: S− call.

presentation of food. One daily training session consisted of 80 trials. The trials in which the subject showed a response for S+ and no response for S− were counted as correct, and the trials with no response to S+ and response to S− were counted as incorrect. Responses during the correction trials were not used for analysis. This training procedure continued until the subject showed more than 70% correct trials in 3 successive sessions. Then the subjects received the following tests. The training was inserted between the test sessions described below to maintain the discrimination level.

Test 1. The test consisted of 96 trials in which 4 categories of stimuli appeared, namely, the original stimuli (24 S+ trials and 24 S− trials), visual S+ and S− without auditory stimuli (8 trials each), auditory S+ and S− without visual display (8 trials each) and combinations of visual and auditory stimuli in which one modality of S+ was combined with another modality of S−(8 trials for each combination). In the last 3 categories, half of the element stimuli had not been presented during the training sessions. Correct response for the training stimuli was reinforced while no reinforcement was given for the other stimuli. The birds received this test 3 times.

Test 2. The test consisted of 96 trials, in which 4 categories of visual stimuli appeared, namely training stimuli (24 S+ and S− trials each), combination of the S+ bird's head and the S− bird's body, and combination of the S− bird's head and the S+ bird's body. These combined stimuli were presented under 3 auditory conditions, namely, S+ bird's call, S− bird's call and no auditory stimuli (8 trials for each combination under each auditory condition). Reinforcement was available for the training stimuli, while it was not available for response to other stimuli. This test was repeated 3 times.

Results

All birds successfully learned the discrimination task. The fastest bird reached the criterion within 10 sessions; the slowest bird did so in 18 sessions. Three birds showed over 90% correct response in the final session of the training.

Figure 2 presents results of Test 1. A statistical analysis of responding to all stimuli containing visual S+ and visual S− gave a significant difference between the two in every bird (Chi-square ranged from 9.2 to 56.1, $P < 0.005$, $df = 1$). On the other hand, an analysis be-

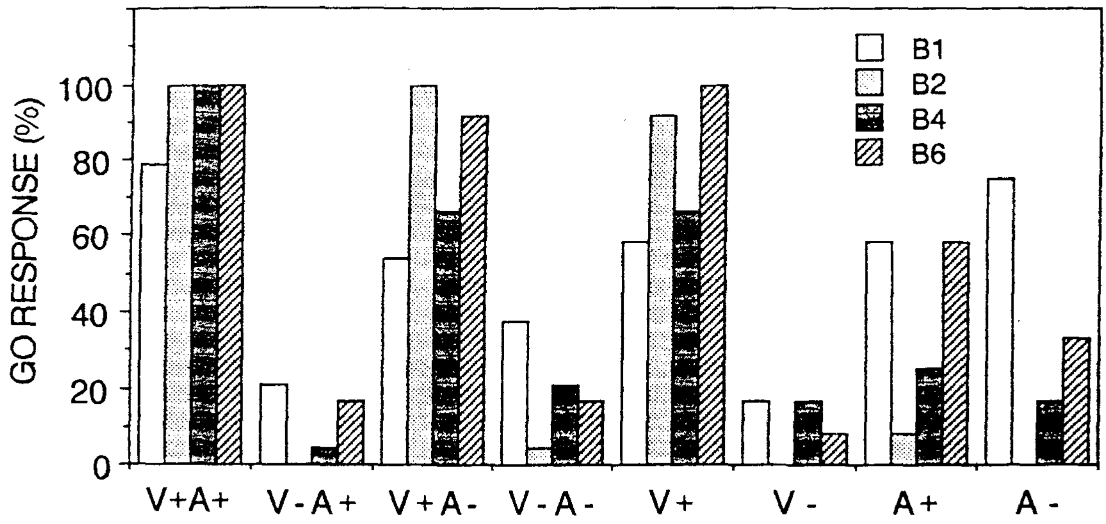

Fig. 2. Results of Test 1. V and A indicate visual stimulus and auditory stimulus, respectively.

tween responses to all stimuli containing auditory S+ and those containing S− revealed no significant difference (Chi-square ranged from 0.8 to 3.5). When visual stimuli appeared without auditory stimuli, the birds maintained the discrimination. Difference between visual S+ and S− was significant in B2, B4 and B6 (Chi-square, 16.8, 4.3 and 16.8, respectively, $P < 0.05$). B1 showed a weak significant difference (Chi-square, 2.84, $P < 0.10$). However, they did not maintain their discriminative behavior when only auditory stimuli were available. No birds significantly discriminated when auditory stimuli alone were presented (Chi-square ranging from 0 to 0.67). Responses for compound stimuli support these observations. The birds reacted to the combination of visual S+ and auditory S− but not to the combination of visual S− and auditory S+ (Chi-square for B1, B2, B4 and B6 were 0.76, 40.4, 8.5 and 24.3 respectively; the values were significant at $P < 0.05$ level except for B1).

Sex difference of the subjects was not significant for the visual cue alone, the auditory cue alone or the combined cues (Chi-square ranged from 0.01 to 0.29, df = 3).

Figure 3 shows results of Test 2. Every subject maintained discrimination for the original training stimuli (Chi-square for difference between the columns H+/T+ and H−/T− ranged from 7.2 to 21.8, $P < 0.05$, df = 1). The auditory condition did not have a significant effect on discrimination with these original stimuli except for B6 (Chi-square, 6.9, $P < 0.05$, df = 2). When the chimera stimuli appeared, B1 and B4 responded often to a combination of S+'s trunk and S−'s head but not to a combination of S+'s head and S−'s trunk (Chi-square, 17.4 and 21.6, $P < 0.005$). A similar tendency was also observed in B2 and B6 but a statistical analysis gave no significant difference (Chi square, 1.8 and 2.5, p = 0.18 and 0.11 respectively). B2 and B6 showed auditory stimulus control when visual stimuli con-

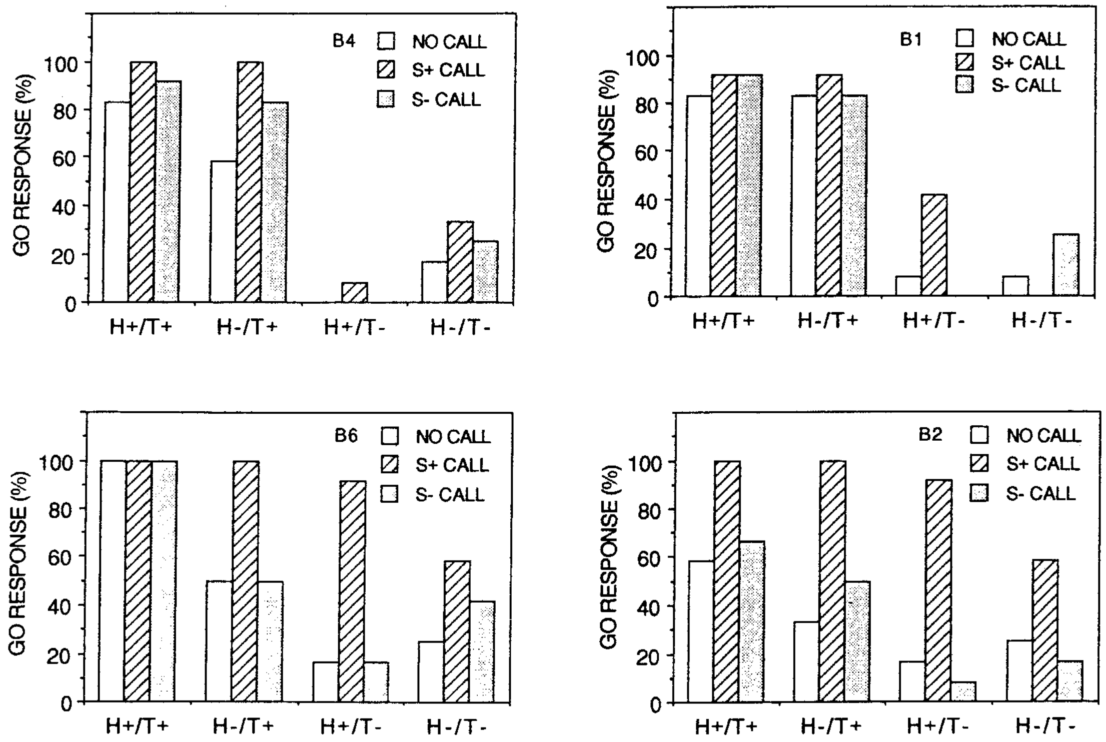

Fig. 3. Results of Test 2. H and T indicate a head and a trunk of the stimulus birds, respectively. These visual stimuli were presented under 3 auditory conditions, namely no call, the S+ call and the S− call.

sisted of a combination of S+ and S−. They responded often to these stimuli when the auditory stimulus was the S+ call. A statistical analysis indicated a significant effect of the auditory condition on responses to the chimera stimuli (Chi-square, 15.2 and 12.7, $P < 0.005$, $df = 2$). The other 2 birds (B1 and B4) did not show such auditory stimulus control (Chi-square, 1.8 and 2.9). Because B1 and B2 were female and B4 and B6 were male, the difference in auditory stimulus control did not result from sex difference.

Discussion

Our birds successfully learned individual discrimination. This result supports our previous finding in which only visual cues were available (Watanabe et al. 1993). Furthermore, the present results clearly showed selective stimulus control with visual signal in conspecific individual discrimination. It may be, however, premature to conclude dominance of visual cue over auditory cue in individual discrimination of Bengalese finches in general. Psychophysical difference between the 2 discriminative calls may be smaller than that between the visual images. Bengalese finches use their contact calls in their social interaction, so discriminative training with colony mates with calls familiar to subjects may have a different result.

Because the 2 stimulus birds were of different sexes and Bengalese finches have sexual dimorphism in the auditory signal, there is a possibility of auditory sex discrimination rather than individual difference. On the other hand, there is no sexual dimorphism in visual appearance. Dominant stimulus control by the visual signal indicates that the birds learned individuals rather than sex.

Another important finding of the present experiment was that auditory covert stimulus control appeared to be overt in some birds when the visual cues gave ambiguous information. There have been many operant experiments using compound discriminative stimuli consisting of 2 or more elements (for example, discrimination between a red triangle and a green circle). Exclusive stimulus control by one of the elements (for example, color) has been well reported (eg Reynolds 1961). Although most of these experiments employed 2 stimulus dimensions on 1 sensory modality, the present results agree with such findings of selective stimulus control. Wilkie and Masson (1976) reported exclusive stimulus control by color cue in a test with element stimuli after discrimination of compound stimuli consisting of shape and color in pigeons. Furthermore, they found that the birds showed rapid acquisition of a shape discrimination in which the shape previously associated with reinforcement was S+. Thus, they found that learning of a less dominant element becomes overt under some conditions. In this experiment, stimulus control with auditory signal was not observed in Test 1. The auditory stimulus, however, controlled discriminative behavior of 2 birds when the visual signal gave the birds ambiguous information (Test 2). This observation suggests that covert auditory discrimination occured in these birds. Although 2 other birds showed exclusive stimulus control by visual signal, the presence of the secondary effective signal seemed to be adaptive. Our animals might have used the second cue when the first cue did not provide enough information.

With regards to visual cues, the trunk was more important than the head. For the human observer, the trunks differed more than the head between the 2 stimulus birds. Dominant stimulus control by the trunk part may have resulted from these differences in discriminability.

Acknowledgements — The authors wish to express their gratitude to Mr. C. Bolongan for his stylistic corrections and also to Mr. M. Wakita for his technical assistance. This research was supported by Grant-in-Aids-for-Promotion-of Sciences (#05206113)

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(Received 18 February 1993 ; Accepted 24 June 1993)

Published by Japan Ethological Society, Department of Zoology, Kyoto University, Sakyo, Kyoto, 606 Japan