Aggressive motivation in *Betta splendens*: Replication and extension¹

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In two experiments with male Ss, mirrors were more effective than live male fish in eliciting aggressive displays; Ss displayed less frequently but spent more time viewing both stimuli during continued or repeated exposure to them. Presence of a female Betta decreased display frequency to mirror but did not affect display frequency to male. Responsiveness to live fish was more consistent than that to mirrors.

EXPERIMENT 1

Siamese fighting fish display aggressively to conspecific males and mirror images. Baenninger (1966) found that male *Bettas* showed a waning tendency to approach display-eliciting stimuli and, in addition, that Ss spent more time before mirror images than conspecific males. That experiment was replicated in the present experiment but gill cover extension frequency was also recorded, unhabituated male stimulus fish were used, and the motivating effect of a female on male aggressive behavior was studied. Kuhme (1963) noted that movement patterns of aggressive display were similar to sexual display patterns. Thus, the possibility exists that a female's presence may increase the frequency of intermale aggressive displays.

Method

Twelve male *B. splendens*, purchased from a local dealer, were isolated in small containers for 2 weeks prior to experimentation. From these, six were randomly selected as Ss and the remaining six were used as stimulus fish. Six females were kept in a communal tank when not used.

A glass, 5-gal tank (16½ x 8½ x 10½ in.) was filled to a depth of 3½ in. The stimulus fish, kept in an adjoining glass container which conformed to its sixth of the tank, was visible to S only when he was in the end sixth of the tank; a mirror was visible to S only when he was in the other end sixth. A breeder net (5½ x 3 x 3 in.) housed the female.

The procedure was modeled after Baenninger's study (1966). The tank was divided into three parts: end areas each comprised 1/6 of the total volume; the center took up the remaining 2/3. In the control condition, S remained in the tank

for 32 consecutive hours and 15-min observations were made after 0, 1, 2, 4, 8, 16, and 32 h. Experimental Condition 1 followed in which a stimulus male was visible from one end area and a mirror from the other, while neither was visible from the center. Experimental Condition 2 was identical except that a female *Betta* was kept in an immersed breeding net in the central area of the tank. There was a 16-h interval between each condition, during which S was removed to a small container and fed and the water in the experimental tank was changed.

Data recorded included time spent in each portion of the tank and frequency of gill cover extensions (GCE). Experimental conditions were presented in a counter-balanced order. Indirect lighting kept the tank constantly illuminated, and water was maintained at 75 deg F.

Results

With no female present Ss spent a decreasing amount of time in the center of the tank where neither mirror nor live fish were visible, thus reversing the finding of Baenninger's earlier study (1966) in which a habituated nondisplaying stimulus fish was used ($r_s = -0.75$, $p < .05$). With a female present this trend did not appear ($r_s = -0.61$, $p > .05$), nor did any temporal trend appear in the control condition.

There was a decreasing tendency for Ss to display in both 32-h experimental conditions, replicating the finding by Clayton & Hinde (1968) that habituation of gill cover extensions occurs (without female: $r = -0.78$, $p < .025$; with female: $r = -0.87$, $p < .01$). Ss never displayed in the center of the tank to any significant extent in the absence of a female.

In the control condition Ss spent an amount of time in each end equal to that spent in the central two-thirds of the tank. Without the female in the center, but with a mirror in one end and a live fish at the other, the overall ratio of "mirror time" to "fish time" was 2.1:1, but with a female present in the center this ratio fell slightly to 1.7:1. The mirror image was more attractive than the live fish; in both conditions Ss alternated between the mirror and the male, and the female when she was present.

The Ss displayed more frequently to their mirror images when the female was absent, but no difference in the frequency of GCEs to mirror and live male opponents was shown with a female in the center of the tank (Fig. 1). The ratio of the number of

GCEs in each area of the tank varied significantly as a function of experimental condition ($\chi^2_R = 8.5$, $p < .01$) with the fewest displays in the center without the female, and no difference when the female was present. Male Ss spent significantly more time in the center when the female was present there, however ($\chi^2_R = 8.5$, $p < .01$).

The total number of GCEs was almost the same in both experimental conditions; none were made in the control condition. More mirror displays occurred in Experimental Condition 1 (female absent) than in Experimental Condition 2 (female present) ($t = 2.1$, $p < .05$). Conversely, more center area displays were made during Condition 2 than during Condition 1 ($t = 1.85$, $p < .05$), this difference reflecting Ss' displays to the female housed in the center. When considering displays presented to the male stimulus *Betta*, no significant difference was found between Conditions 1 and 2.

Discussion

Time spent in front of display-eliciting stimuli increased while gill cover extensions decreased during 32-h trials, as estimated from seven regular 15-min observations. With a female present, there was no trend toward staying away from the tank center: Ss spent a large amount of time near the female in the center throughout the observation. The reversal of Baenninger's earlier (1966) finding is probably attributable to use of an unhabituated male stimulus fish in the present experiment.

In the control condition Ss made no GCEs at all because no sign stimulus was present,

Fig. 1. Total number of displays, displays to mirror (M), displays to live fish (LF), and displays in center of tank (C) during seven 15-min observations without a female and seven observations with a female present in the center of the tank.

Fig. 2. Mean number of gill cover extensions during 15 min by 10 Ss. Each observation was separated by 1 week. M = Mirror observation; LF = live male fish present in adjacent tank during observation.

but overall GCEs were almost equal in Conditions 1 and 2. Superficially, this would seem to indicate that the aggressive display of male *Bettas* is little affected by a female's presence. However, while not affecting total number of GCEs, the female clearly altered the distribution of displays in each area of the tank. In the female's absence, Ss displayed primarily before the mirror; with a female, displays were about equally distributed among the three areas of the tank. When the female was absent the center area was an "escape" region, devoid of stimuli, and there were almost no displays there. Ss displayed to the female when she was present in the center area, and performed fewer GCEs to the mirror image; display frequency to the male stimulus fish was maintained. Displaying males attempted to break into the breeder net, and although these sexual displays were similar in kind to aggressive displays made to males (Kühme, 1963), movements were slower, with less thrashing and more biting.

EXPERIMENT 2

The preference for mirror image stimulation found in Experiment 1, and the greater frequency of gill cover extensions to mirror images, could conceivably be limited to situations in which S is free to move between a mirror, a conspecific male, and no stimulation. Accordingly, the frequency of GCE to mirrors and conspecific males was investigated by presenting these stimuli to male *Bettas* for 15-min periods separated by intervals of 1 week, in a situation where Ss were not free to move away from them.

Method

Ten naive male *Bettas* were isolated for 2 weeks prior to experimentation. Observations were made while Ss were in their home containers (500-ml rectangular glass jars). A mirror or a stimulus fish in a similar jar was placed against one wall of S's container of 15 min and the frequency of GCEs was

recorded. Observations were made at weekly intervals between 2 and 4:30 p.m. in the following order: mirror, habituated male, habituated male, mirror, unhabituated male, unhabituated male, mirror.

Results

Gill cover extensions were performed more frequently to mirrors than to live males during the first four observations ($t = 2.4$, $p < .01$). A significant positive correlation was found between the GCE frequency to live fish in Sessions 2 and 3 ($r = 0.62$, $p < .05$), but not between GCEs to mirror images in Sessions 1 and 4 ($r = 0.33$, $p > .05$). The sum of GCEs in the two mirror sessions was positively related to the sum of GCEs in the sessions with live males as stimuli ($r = 0.70$, $p < .05$).

In the last four sessions no difference was found between displays to mirrors and live fish, presumably because of diminished responding to the mirror in the final observation. Again, a positive correlation between GCEs to live fish in Observations 5 and 6 was found ($r = 0.84$, $p < .01$) but not between Mirror Sessions 4 and 7 ($r = 0.48$, $p > .05$). Waning of responsiveness to mirrors was found in this experiment, even though observations were always separated by 1 week: Only two Ss displayed to mirrors in Observation 7, while nine did so in Observations 1 and 4. Evidence that some Ss showed waning responsiveness to live fish was also found: In Observations 2, 3, 5, and 6 there were 7, 6, 7, and 3 Ss which showed displays, respectively.

Discussion

Quite clearly, the increased effectiveness of mirrors over live males as display-eliciting

stimuli is not limited to preference situations. The responsiveness of a given S was more consistent to live fish than toward mirror image opponents, due perhaps to the fact that a mirror image opponent behaves consistently only to the extent that S's behavior is consistent while a live opponent may behave consistently independently of S. Gallup (1968) has suggested that the effectiveness of mirror image stimulation may be due to its novelty. If this were the case, one might expect a more rapid habituation to mirror images than to live fish, the responsiveness to the latter being due presumably to something besides novelty. No clear evidence of such a differential waning has been found in these experiments or in previous work with *B. splendens* (Baenninger, 1966, 1968).

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Reversal learning in the sow bug¹

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Three groups of four sow bugs each were taught a turning response in a simple T-maze. One group, acting as a control, learned a single turning response. The other two groups were taught successive reversals according to a learning criterion or a trials criterion. Under the conditions of this study, sow bugs demonstrated statistically significant improvement in successive reversal learning.

Previous research has shown that sow bugs are capable of learning only relatively simple tasks. Frost (1967) has reported that sow bugs can readily master a single turning response in a simple T-maze. Thompson (1957), on the other hand, found sow bugs

unable to show progressive improvement in habit reversal over a number of days. Thompson ran each S eight trials per day in a simple T-maze using electric shock as a negative reinforcer and a dark, damp goal box as the positive reinforcer. After reaching a criterion of seven out of eight responses correct, the correct arm of the maze was reversed until criterion was again reached. Seven Ss were trained until each had completed eight reversals; no significant improvement over reversals was shown. Ratner & Denny (1964, p. 634) suggested that under more favorable circumstances sow bugs could probably demonstrate reversal learning. Since most isopods are negatively thermotaxic, it was decided for the present study to use a more salient negative reinforcer, extreme heat, and also to mass practice during training.