Bulletin of the Psychonomic Society
1980, 16 (6), 458-460

Extinction of contextual fear and preference for signaled shock

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Rats received signaled shock on one side of a shuttlebox and unsignaled shock on the other. After reaching a criterion preference for the signaled side, the experimental group was given Pavlovian extinction of contextual fear of the unsignaled side. The control group received equivalent exposure to a novel control chamber. Extinction of fear of the unsignaled side reduced the preference for signaled shock. This finding suggests that preference for signaled shock is mediated by contextual fear.

The rat finds a situation in which a painful electric shock is preceded by an explicit stimulus preferable to a situation in which the same stimulus is delivered unsignaled. This preference for signaled shock (PSS) has generated considerable experimental and theoretical attention. As the PSS literature has recently been subjected to several extensive reviews (Badia, Harsh, & Abbott, 1979; Fanselow, 1980; Hymowitz, 1979), I will not attempt to review it here. Rather, the present paper will report on an experiment that tests a straightforward prediction from the most recent model of PSS, the contextual-fear hypothesis of Fanselow (1980).

Fanselow (1980) points out that when shock is signaled by some stimulus, modern theories of Pavlovian conditioning (e.g., Rescorla & Wagner, 1972) lead us to expect that less fear would be conditioned to contextual stimuli than if the shocks were unsignaled (Baker, 1977; Baker & Mackintosh, 1979; Odling-Smee 1975, 1978; Rescorla, 1972). The contextual-fear hypothesis of PSS adds only one simple performance rule to these Pavlovian principles: Rats withdraw from the contextual stimuli that elicit the most fear.

As a test of the contextual-fear hypothesis, Fanselow (1980) allowed rats to choose between a place in which a brief signal was negatively correlated with shock and a place in which the same shock was delivered but no signals were presented. According to the Rescorla-Wagner (1972) model, such a negatively correlated signal should increase contextual fear relative to the unsignaled-shock context, and, consistent with the contextual-fear hypothesis, the rats chose the unsignaled-shock condition.

The negatively correlated cue provided information about shock-free time; so both the information hypothesis (D'Amato & Safarjan, 1979) and the safety signal hypothesis (e.g., Badia & Culbertson, 1972) predict a preference for the situation in which the negatively correlated cue occurred. Since the negatively correlated cue situation provided no information temporally accurate enough for the timing of a shock-modulating preparatory response, the preparatory response hypothesis (Perkins, 1968) predicts that the animals should find the negatively correlated signal situation and the unsignaled situation equally aversive. So, this aversion to the place at which the negatively correlated signal occurred, while supporting the contextual-fear hypothesis, runs contrary to predictions made by these other formulations that are often invoked to explain PSS.

According to the contextual-fear hypothesis, any manipulation that influences contextual fear should have a predictable influence on PSS. One such manipulation is Pavlovian extinction of contextual fear. When an animal is exposed to frightening contextual stimuli, in the absence of shock, contextual fear undergoes extinction; fear of the context is reduced (Bouton & Bolles, 1979b; Dweck & Wagner, 1970). Since, according to the contextual-fear hypothesis, rats prefer signaled shock because contextual fear is greater in the unsignaled-shock situation than in the signaled-shock situation, reduction of contextual fear in the unsignaled-shock situation, via contextual extinction, should reduce the preference.

To test this prediction of the contextual-fear hypothesis, rats were given a choice of signaled shock on one side of a shuttlebox and unsignaled shock on the other. When the rats reached a criterion preference for the signaled side, they were confined to the unsignaled side. Control rats, also trained to the same criterion, received an equivalent amount of confinement but in a novel chamber. Following this confinement period, the rats' side preferences were tested.

This research was conducted in the laboratory of Robert C. Bolles while the author was a graduate student at the University of Washington. The author would like to thank J. Stewart for her help in running the animals. Address any correspondence to: Michael S. Fanselow, Psychology Department, Rensselaer Polytechnic Institute, Troy, New York 12181.

METHOD

Subjects

The subjects were eight adult lean (FA/–) Zucker male rats weighing between 350 g and 500 g at the start of the experi-

0090-5054/80/120458-03$00.55/0

ment. The subjects were housed individually and handled daily for at least 3 weeks before the experimental procedure began. The animals were maintained on a 12-h/12-h day/night cycle, and the experiment was conducted during the "lights-on" portion of the cycle.

Apparatus

A 76 x 20 x 18 cm shuttlebox was used. One compartment of the box was painted with 2.5-cm-wide black and white vertical stripes and the other compartment had similar stripes 1 cm wide. The lid of the shuttlebox was clear plastic. A removable clear plastic partition was used to confine the subjects to the unsignaled-shock side of the shuttlebox during extinction. The grid floor consisted of 1-cm stainless steel rods spaced 2.5 cm center to center. The grid floor was connected to a Grason Stadler shock generator/scrambler that provided a .75-sec 1.0-mA scrambled electric shock.

The 20-sec signal was the "clatter" produced by an electromechanical flip-flop switched 5 times/sec by an electromechanical multivibrator. The signal was 80 dB (linear scale, background 61 dB). The signal provided frequencies in the range of 250 Hz to 8 kHz, with amplitudes above the background noise level.[1]

The novel confining chamber was a 24 x 23 x 20 cm brown Masonite box. One wall (24 cm), which constituted the door, was clear plastic.

Procedure

A rat was placed in the shuttlebox for a maximum of five daily 44-min periods for a maximum of 3 days. Each period contained 10 presentations of the shock. Shock was presented on a VT 240-sec schedule, with intershock intervals distributed irregularly between 580 sec and 80 sec.[2] For four of the animals, the wide-striped side was designated as the signaled side; the other four animals received signals on the thin-striped side. On the signaled side, the clatter was sounded for 20 sec before delivery of the shock. On the unsignaled side, no signals were ever presented. Shuttling from the signaled side to the unsignaled side during a scheduled signal presentation resulted in the immediate offset of the signal, and crossing in the opposite direction had the opposite consequence. The rat could not affect delivery of the shock.

After a 44-min period expired, the rat was removed from the shuttlebox and the data were recorded. The rat was then placed on the side of the shuttlebox opposite from where it had been removed for the next 44-min period. The rat received this treatment until it spent 75% of three consecutive periods on the signaled side.

The day after the rat reached its criterion, it was assigned to either the experimental or the control group. Experimental animals were given contextual-fear extinction training. This was achieved by confining them to the unsignaled side of the shuttlebox for five 44-min periods. The rat was picked up out of the unsignaled side and then replaced in it between periods. The control animals were confined to the novel confining chamber for an equivalent amount of time and given equivalent handling. No shocks or signals were presented to either group during extinction training.

On the day following extinction training, all the rats were given the same preference test. A rat was placed on one side of the shuttlebox and allowed to explore it freely for 5 min. It was then removed from the shuttlebox and placed on the side of the box opposite to its initial placement for a second 5-min test.

RESULTS

The data of all animals are presented in Table 1. The animals in the experimental group reached the preference criterion in a mean of 7.75 periods (77.5 shock trials), which was not different from the controls, which reached the criterion in 6.75 periods (67.5 shock trials).

The percentage of time the animals spent on the signaled side during the two five-min preference tests did not differ. For each animal, the mean of the two tests was determined, and this mean is presented in the fifth column of Table 1. The experimental animals spent 60% of their time on the signaled side, significantly less than the controls, which spent 48% of their time on the signaled side [$t(6) = 4.76$, $p < .01$]. Note that there is no overlap between the experimental and control groups (Mann-Whitney $U = 0$, $p < .05$).

Table 1

Subject	Condition	Side*	Periods**	Time†
1	E	W	4	.66
5	E	T	9	.63
7	E	W	10	.62
8	E	T	8	.50
2	C	T	3	.71
4	C	T	10	.98
6	C	W	6	.75
9	C	W	8	.92

Note—E = experimental; C = control. *Side on which signal appeared: W = wide striped; T = thin striped. **Periods to PSS criterion. †Mean percent of time on the signaled side during the preference tests.

DISCUSSION

The contextual-fear hypothesis states that PSS is a function of the difference between the contextual fear of the signaled- and unsignaled-shock situations. Signaling the shock supposedly causes a reduction of contextual fear relative to the unsignaled context, and the magnitude of this difference determines PSS. By extinguishing contextual fear on the unsignaled side, the present experiment reduced the difference in contextual fear of the two sides, and consistent with the contextual-fear hypothesis, there was a reduction in the strength of the preference for signaled shock.

It should be noted that the information hypothesis (D'Amato, 1974), the safety signal hypothesis (Badia & Culbertson, 1972; Seligman, 1968), and the preparatory response hypothesis (Marlin, Berk, & Miller, 1978; Perkins, 1968), the theories most often provided for PSS, do not predict these results unless some additional post hoc assumptions are made. One advantage of the contextual-fear hypothesis over these earlier theories of PSS is its ability to make testable predictions, such as the one made here. This may be contrasted with the other three hypotheses, which lead to different predictions in the hands of different investigators (contrast Badia, Harsh, Coker, & Abbott, 1976, with Safarjan & D'Amato, 1978, or contrast Marlin, Sullivan, Berk, & Miller, 1979, with D'Amato & Safarjan, 1979, see Fanselow, 1980, for how the contextual-fear hypothesis handles these differences).

The present data join a growing body of literature that attests to the importance of contextual stimuli in the control of behavior (e.g., Baker, 1977; Bouton & Bolles, 1979a, 1979b; Dweck & Wagner, 1970; Fanselow, 1980, in press; Kremer, 1974; Odling-Smee, 1975, 1978; Pearce & Hall, 1979; Rescorla, 1972; Sheafor, 1975; Siegel, 1977; Tomie, 1976; Wagner, 1976;

Bouton, Note 1). When PSS was first discovered (Lockard, 1963), it presented a paradox to the traditional view of the signal as an aversive elicitor of fear and anxiety (Estes & Skinner, 1941; Mowrer, 1939). The paradox was that if both the signal and the shock are aversive, why does the rat choose the signaled-shock situation, with its two aversive stimuli, over the unsignaled-shock situation with only one aversive stimulus? We now see that this paradoxical finding fits nicely into the mainstream of modern Pavlovian theory.

REFERENCE NOTE

1. Bouton, M. E. *Role of contextual stimuli in the effect of US inflation following fear conditioning*. Paper presented at the meeting of the Eastern Psychological Association, Hartford, Conn., April 1980.

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NOTES

1. Decibel readings were taken at a number of specific frequencies between 31 Hz and 16kHz. The author will provide this information upon request.

2. The time before the first shock presentation in a period and the time after the last shock presentation in a period were not included in the calculation of the mean intershock interval.

(Received for publication November 24, 1980.)